Executive Summary

The CDFs (Core Distributed Interactive Simulation Facilities) are DIS (Distributed Interactive Simulation) Confederation facilities consisting of virtual simulators and other simulation assets available for DoD or commercial customers to conduct DIS experiments and exercises. CDF sites include the Mounted Warfare Test Bed (MWTB) at Fort Knox, Kentucky; the Aviation Test Bed (AVTB) at Fort Rucker, Alabama; the Land Warrior Test Bed (LWTB) at Fort Benning, Georgia; and the Operational Support Facility (OSF) at Orlando, Florida. The upgrade was performed as Delivery Order (DO) #0013 under the Lockheed Martin Advanced Distributed Simulation Technology II (ADST II) Contract administered by the U.S. Army Simulation, Training, and Instrumentation Command (STRICOM). STRICOM, as the Program Manager for the CDFs, is responsible for operation, maintenance and modernization of the CDFs.

Currently, most of the CDF simulators provide limited environment simulation (clear day, limited sensor capability) and limited battlefield visualization (exceptions are the M1A2, LOSAT, AWC, RWA/FWA and NLOS simulators). Existing terrain databases are of limited size, and support limited out-the-window and sensor ranges. The infrastructure at the CDFs including local area networks, cell interface and cell adapter units, 2D/3D viewers, radios, data loggers, after action review systems, etc. consists of a wide variety of legacy equipment. Some of this equipment is obsolete and little used.

~~This DO upgraded the RWA/FWA simulators at the AVTB with state of the art PC based image generators in combination with a PC based Host. This combination places the simulation devices at AVTB at the forefront of technology. This technology leading effort demonstrates that the PC can be used to replace larger more expensive dedicated hardware.~~ This DO upgraded the RWA/FWA simulators at the AVTB with state of the art PC based image generators in combination with a PC based Host. This combination places the simulation devices at AVTB at the forefront of technology. This technology leading effort demonstrates that the PC can be used to replace larger more expensive dedicated hardware. To take advantage of the increased performance of the new IG, the out-the-window displays were replaced with high resolution wide field-of-view LCD projectors in a rear projection configuration. This display system is a low cost state-of-the-art display system that exceeds commercially available wide-screen displays ~~To fully take advantage of the new IG the out-the-window display system was replaced with a high resolution wide field-of-view LCD rear projection system that is also state of the art technology. The ability to reconfigure and upgrade these systems with inexpensive off the shelf components assures that they will stay on the leading edge of technology for the foreseeable future.~~ The ability to reconfigure and upgrade these systems with inexpensive off the shelf components assures that they will stay on the leading edge of technology for the foreseeable future.

This DO upgraded the CDFs by providing the infrastructure for the next generation of CDF simulators (CCTT and BLRSI devices), and enhanced the capability to fully simulate weapons systems (including sensor models, weapons models, communication, battlefield representation).

The objectives of the effort were:

- Prepare the CDFs for the implementation of new simulators such as Close Combat Tactical Trainer (CCTT) and Battle Lab Reconfigurable Simulator Initiative (BLRSI).
- Improve support for synthetic environment experiments.
- Increase CDF operational efficiency.

- The enabling technologies for the CDFs continue to develop rapidly. The CDFs must be continuously upgraded to support future experiments that will incorporate these new technologies.
- Requirements are to be prioritized to maximize the usefulness of the CDFs to their mission.

The CDF Upgrade DO accomplished its mission to prepare the CDFs for new simulators and improve our capabilities to support future experiments. Based on the experience gained from this DO additional upgrade requirements have been identified that are necessary to provide a robust and viable environment for future synthetic environment experiments. The new requirements focus on the way the CDFs participate with other sites to perform experiments on the interoperability of the simulators and on new simulator capabilities. And, forming a base to support the future requirements, the CDF and operations will require continuous improvement.

1.0 INTRODUCTION

1.1 Purpose

The purpose of this final report is to document the ADST II Core DIS Facilities (CDF) Upgrade DO effort which supported the CDF Upgrades. This report includes a full description of the upgrades, integration and testing, and lessons learned. For additional information the CDRL test plans, briefings and design reviews are available from the ADST II library.

1.2 Contract Overview

The CDF Upgrade was performed as DO #0013 under the Lockheed Martin Information Systems (LMIS) ADST II contract number N61339-96-D-0002 with STRICOM. The contract required LMIS to prepare the CDFs for the implementation of new simulators such as Close Combat Tactical Trainer (CCTT) and Battle Lab Reconfigurable Simulator Initiative (BLRSI), improve support for synthetic environment experiments, and increase CDF operational efficiency. A detailed description of the activities and results of the CDF Upgrade effort are documented in this report.

The initial release of this report covers DO #0013 CLIN 4 activities. ~~Revision B of this report covers activities for DO #0013, CLIN 13 (change proposal 2).~~

Revision B of this report covers activities for DO #0013, CLIN 13 (change proposal 2).

Task Overview.

In accordance with the Government SOW, document number AMSTI-96-W006, version 5.0, this Final Report includes a description of the upgrades, the results of the interoperability testing, and the systems used for testing and analysis. This report addresses the interoperability of simulation systems and modifications to both ModSAF and the manned simulators.

Major milestones completed as a part of the CDF Upgrade DO include:

- Development of a DIS protocol translator, or ModSAF Translator (MOD-X), conducted at the Operational Support Facility (OSF) in Orlando, FL from September 1996 through January 1997.
- The network upgrades at the CDFs begun in October 1996 and completed in July 1997.
- The installation of the first CCTT simulator at the OSF, M1A1 #13, completed in January 1997. The installation of the second CCTT simulator at the OSF, M2M3 #13, completed in May 1997.
- The integration into the LWTB of the CCTT simulators, M1A1 #26, and M2M3 #28 completed in June 1997.
- Completion of the development of version 4.1 of the Single Channel Ground and Airborne Radio System (SINCGARS) Radio Model in March 1997.

~~The installation of new Meta VR image generation systems at AVTB for the RWA and FWA simulators, completed in September 1998.~~

~~Installation of out the windo w display devices for the RWA and FWA devices, completed in September 1999.~~

~~Porting of the RWA and FW A host software to a PC, completed in October of 1998.~~

- The installation of new MetaVR image generation systems at AVTB for the RWA and FWA simulators, completed in September 1998.
- Installation of out-the-window display devices for the RWA and FWA devices, completed in

September 1999.

- Porting of the RWA and FWA host software to a PC, completed in October of 1998.

1.3 Technical Overview

This DO upgraded the CDFs by providing the network infrastructure for the next generation of CDF simulators (CCTT and BLRSI devices), and enhanced the capability to fully simulate weapons systems (including sensor models, weapons models, communication, battlefield representation.) The CDF Upgrade DO also investigated the degree to which various manned simulators interoperate with computer-generated forces and each other. The CCTT simulators were tested using ModSAF computer generated forces to determine the level to which the devices would communicate with each other, provide line of sight target recognition, and limited tactical engagement.

The CDF Upgrade DO efforts included:

- **Development and Modification Activities**
  These activities focused on the installation and test of CCTT Quick Start modules at the OSF and LWTB. Interoperability tests were run at each site to test interoperability between CCTT and other DIS assets. A longhaul interoperability test was performed between the OSF and MWTB to test interoperability between the CCTT and the DIS M1A2 simulators. In addition, a CCTT Quick Start development tool was installed at the OSF.

  The RWA host software was ported to a PC as part of the upgrade to the Image Generation (IG) devices at AVTB. The IGs were upgraded from the GT100 series machines to MetaVR PC based devices. This change greatly enhances the imaging capability for the RWA simulators. To take full advantage of the upgraded IGs the out-the-window displays were replaced with high resolution LCD rear projection systems. This display replacement allows the image to be represented at a resolution that takes full advantage of the image generators capability.

- **Site Infrastructure Upgrades**
  Infrastructure upgrade tasks covered implementing a wide range of improved DIS assets for ModSAF, stealth, data logging, data analysis and communications. A network infrastructure was installed to provide network connectivity for the new CCTT and BLRSI devices and the connection to the Internet was improved. Additional peripherals for tapes and CDs were installed to augment operational efficiency.

- **Spare Parts**
  A spare parts supply was established to support the new CCTT simulators and workstations.

- **Hardware and Software Maintenance Contracts**
  Software maintenance contracts were established for critical software that was expected to need upgrades.

- **CDF Functional Upgrades**
  The CDF Upgrade DO provided external disk enclosures with removable disk media to enhance operations especially for classified experiments. The ADST II SINCGARS software was rehosted and upgraded to be compatible with the CCTT SINCGARS.

2.0 APPLICABLE DOCUMENTS

2.1 Government Documents

2.1.1 Test Plans

ADST-II-CDRL-003R-9600245-B	Test Plan for the CDF SINCGARS Model at MWTB
ADST-II-CDRL-003R-9600290-A	Interoperability Tests for the QS Modules at OSF
ADST-II-CDRL-003R-9600302-B	Interoperability Tests for the QS Modules at LWTB
ADST-II-CDRL-003R-9600305-B	Test Plan for the CDF SINCGARS Radio Emulator at AVTB
ADST-II-CDRL-CDF-9700124-A	Long Haul Interoperability Test Plan Between OSF and MWTB
ADST_II-CDRL-CDF98-9900004	Fixed Wing Simulator rehost

2.1.2 Version Description Document

ADST-II-CDRL-003R-9600468-B	Version Description Document for the SINCGARS Simulator 4.1
ADST-II-CDRL-003R-9600485-A	Version Description Document for the SUN5 DCA Tool Set (Rehosted DISAT/Datalogger)
ADST-II-CDRL-CDF-9700092-A	Version Description Document for the SUN5 DIS Translator (MOD-X)
~~ADST-II-CDRL-CDF-9800305~~	~~Version Description Document for Rotary Wing Aircraft and Fixed Wing Aircraft Simulators~~
ADST-II-CDRL-CDF-9800305	Version Description Document for Rotary Wing Aircraft and Fixed Wing Aircraft Simulators

2.1.3 Data Item Description

DI-MISC-80711	Scientific and Technical Reports-	Organization, Preparation and Production
DI-MCCR-80013A	Version Description Document	

2.1.4 Statement of Work (SOW)

AMSTI-96-W006, Version 5.0 ADST II Statement of Work for the Core DIS Facility Upgrade Delivery

3.0 TASK DESCRIPTION

3.1 Development and Modification Activities

3.1.1 CCTT Quick Start Modules

The CDF Upgrade DO was tasked to assess the level of interoperability, if any, that existed between the recently deployed CCTT QS Modules and other DIS simulators/devices which operated on the same protocol standard (2.04). In addition, there was a further requirement to develop a tool, or translator, which would provide interoperability between DIS 2.04 devices and older DIS 2.03 devices.

To satisfy the requirement for DIS 2.03/2.04 interoperability, an Experimental Cell Adapter Unit (XCAU), more commonly known as the ModSAF Translator (MOD-X), was developed. The MOD-X translates 27 standard Protocol Data Units (PDUs) from DIS 2.03 to DIS 2.04, and vice versa, by disassembling, re-packaging and re-transmitting the packets from one side to the other. The tool also serves as a filter by identifying and disregarding any non-standard/corrupted PDU it receives from either side. Refer to Version Description Document (VDD) number ADST-II-CDRL-CDF-97000092-A for additional information on the MOD-X Translator.

A series of interoperability tests were developed and conducted at each of the CDFs (except AVTB). Each test included a MOD-X, one or two CCTT QS Modules, two ModSAF 3.0 workstations (one DIS 2.03 and one DIS 2.04), two CDF SINCGARS 4.1 stand-alone radios (both operating on DIS 2.04) and one DIS 2.03 Simulator (Dial-a-Tank at OSF, M1A2 at MWTB and LOSAT at LWTB). The principal areas of interest for test/evaluation included two-way communication, visibility/line-of-sight and some limited tactical maneuvers/operations on a compatible terrain database (NTC).

The following paragraphs describe each of the interoperability tests within the series. Also refer to the Test Plans listed in paragraph 2.1.1 of this document for a detailed description of each test, and to Appendices B, C and E of this document for the individual Test Reports.

3.1.1.1 MWTB QS Interoperability (Longhaul Test)

The objective of the MWTB Longhaul Test was the network interoperability testing of a variety of entities on a WAN/LAN that spans from the Orlando OSF to the MWTB. Connectivity between the Fort Knox and OSF facility used the Defense Simulation Internet (DSI). This testing included DIS assets including communications that operated with various versions of DIS via the MOD-X translator. The longhaul interoperability test demonstrated the capability to perform a simulation exercise with DIS and CCTT entities at MWTB and OSF using the DSI.

A Longhaul Interoperability Test Plan CDRL AB01 number ADST-II-CDRL-CDF-9700124-A for CDF Upgrade Delivery Order was written, submitted, and approved by STRICOM. The actual longhaul test was performed over a period of three weeks in May 1997. This testing began on May 8 with 'connectivity' testing from OSF to MWTB and included 6 test sessions with the last 'formal' test completed on May 22. See Appendix B for a detailed discussion of the testing environment.

3.1.1.1.1 MWTB Longhaul Test: System/Test Description

The tests conducted as part of the MWTB longhaul test are described in detail in the test plan and the

results are described in Appendix B. To summarize, the test consisted of three groups of tests:

- Communication/Interconnectivity - This testing established continuity of the end-to-end connection of the DSI and all entities in the exercise. Secondly, the audio communication capability was verified by two-way voice communication with the radios.
- Visual Line of Sight and Non Line of Sight - This testing established the appropriate visibility of entities by each of the other entities.
- Limited Tactical Operations - These tests consisted of a series of scenarios with armor and air friendly and OPFOR entities.

The test site database was the NTC (National Training Center) area of the CCTT "Primary 2" database.

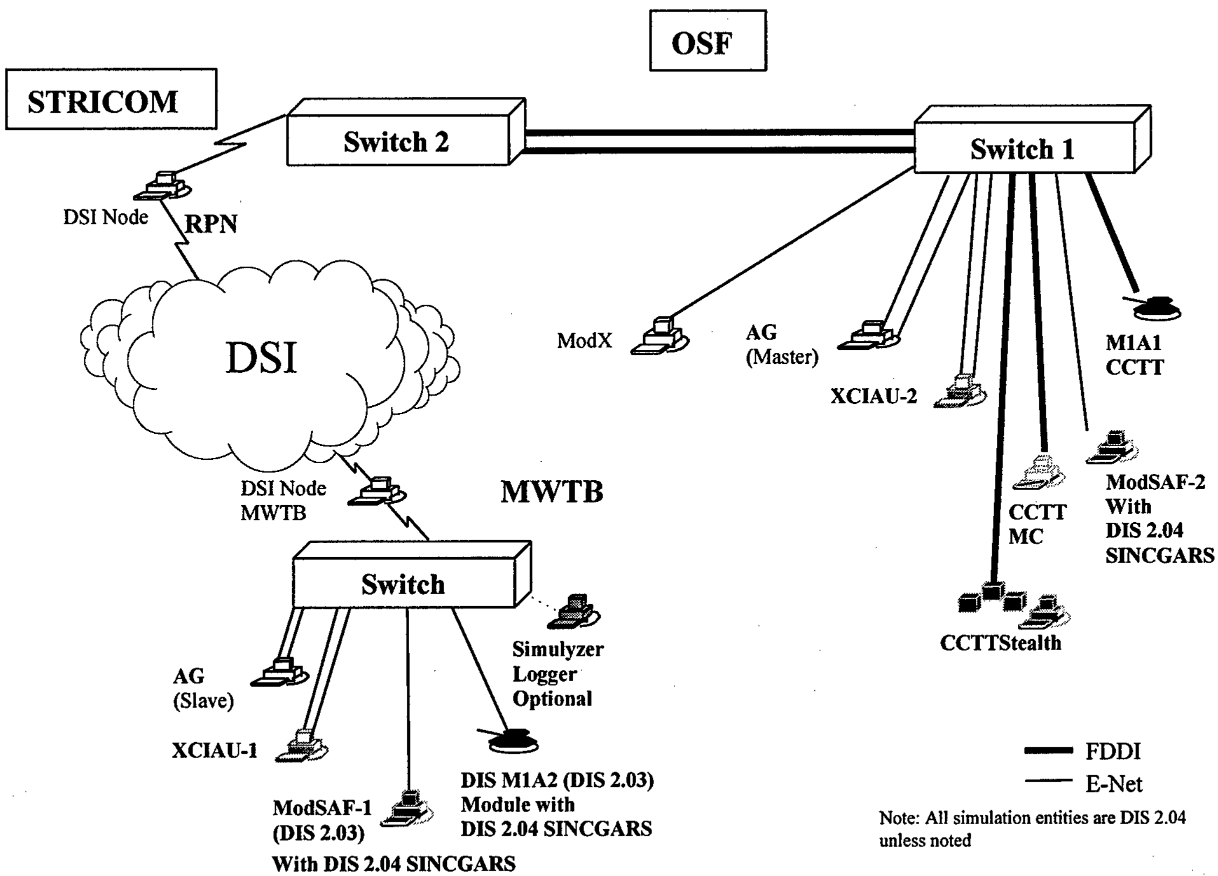

Figure 1 MWTB Test Configuration

The equipment and network configuration for the MWTB longhaul test is shown in Figure 1. The components used for the OSF, DSI and MWTB are discussed in the following paragraphs.

The OSF components used in the test were:

- CCTT M1A1 - This entity is a manned module with 4 manned positions: tank commander, gunner, loader and driver. Each of these positions includes appropriate out the window displays, high power sights and a push-to-talk radio

headset to communicate with others in the module as well as all other entities. The Image Generator used by the M1A1 is an Evans and Sutherland ESIG 3000 specially configured for CCTT.

- Maintenance Console (MC) - The maintenance console is used by the operator to initialize the CCTT M1A1. (The MC at the OSF does not include the PIE cabinet included in training CCTTs.) The MC also serves as the Master Control Console (MCC).
- CCTT AAR/Stealth - The CCTT AAR/Stealth station gives the Observer/Controller personnel a "window" into the virtual battlefield allowing them to make covert observations of the action occurring during the scenario. In addition, through the use of the data logger function, it provides an After Action Review (AAR) capability. (The AAR/Stealth at the OSF does not include the radio channel recording or playback capability included in CCTTs used for training.) The Stealth is a visual display platform that consists of a Plain View Display (PVD), a 3-D spatial orientation input device, and three video displays that provide the operator with a panoramic, 3D view of the battlefield. The Stealth permits the controller to fly around the virtual battlefield and view the simulation without interfering with the action. The features of the Stealth allow the observer to survey the virtual battlefield from a variety of different perspectives, including:
  a. Tethered View - Allows the user to attach unnoticed to any vehicle on the virtual battlefield. The Executive Officer was always tethered to his ModSAF vehicle.

  b. Mimic View - Places the user in any vehicle on the virtual battlefield and provides the same view as the vehicle commander.

  c. Orbit View - Allows the operator to remain attached to any vehicle on the virtual battlefield and to rotate 360° about that vehicle, while still maintaining the vehicle as a center point of view.

  d. Free Fly Mode - Permits independent 3-D movement anywhere in the virtual battlefield.

- MOD-X - The MOD-X provides the capability for translation to/from DIS 2.03 and 2.04 protocols. All devices at the OSF site were DIS 2.04 protocol and all devices at MWTB were DIS 2.03 protocol.
- XCIAU - The XCIAU provides a filtering capability, which can pass selected PDUs. It also provides a log of how many of each type of PDU is received and passed.
- Simulyzer™ - The TASC Simulyzer™ is a DIS diagnostic tool and data logger that was used during the course of the test to help troubleshooting.
- Application Gateway (AG) - The AG was intended to be used as the gateway from the DSI to the two facilities. It provides entity information and quantities serving as a barometer of the test configuration. Our experience with the AG was that it was not beneficial, did not operate properly, and ultimately it was not used in our tests.

- ModSAF -ModSAF version 3.0 was used for the longhaul test. ModSAF entities were used to tether CDF SINCGARS and establish a TOC as a command and control center. OPFOR ModSAF provided the tank platoons required for the exercise. OPFOR were provided in a configuration of a tank platoon and helicopter flight of 5 to complete the scenario requirements.
- SINCGARS Radio - This standalone radio was tethered to TOC1 and provided communication with TOC2 at the OSF site and the M1A1 module. The SINCGARS systems were configured to run using DIS 2.04. The CCTT SINCGARS was used in the M1A1.

The MWTB devices used in the test were:

- M1A2 - This DIS 2.03 entity is a manned module with 4 manned positions: tank commander, gunner, loader and driver. Each of these positions includes appropriate out the window displays, high power sights and a push-to-talk radio headset to communicate with others in the module as well as all other entities. The image generator for the M1A2 is a Vistaworks 6.1.0B with an S1000 format database running on an SGI Onyx series image generator.
- ModSAF 3.0 - ModSAF was used for a second TOC. ModSAF provided the Tactical Operations Center (TOC2).
- SINCGARS Radio - This standalone radio was tethered to TOC2 and provided communication with TOC1 at the OSF site and the M1A2 module.
- XCIAU - The XCIAU provides filtering capability that can selectively pass PDUs. It also provides a log of how many of each type of PDU are received and transmitted.

As shown in Figure 1, the DIS connection from the OSF was established via the 10BaseT Ethernet connection to STRICOM via the Research Park Network (RPN).

The DSI network was used to connect STRICOM with the MWTB. The DSI system includes a BBN manufactured T/20 gateway with T1 links at each site and the necessary routing/bridging services provided by Houston Associates Inc. (HAI) to provide connectivity between the two sites.

The DSI provides a theoretical bandwidth for non-secure (not encrypted) exercises of 1.54 megabits per second. In practice a more conservative ceiling for bandwidth limit, which we used, is 1.2 Mb/sec. It is the user's challenge to utilize this bandwidth as efficiently as possible. At the start of the exercise, the user must configure the 'stream' for transmitted data packets.

The equation for computing bandwidth is:

$$B = P * (N-1) * 8 * U$$

Where,

P = packet size in bytes (for our test = 332 eight-bit bytes)

N = number of sites (for our test = 2)

U = packet update rate (packets/second, for our test = 450)

For our test we set the maximum packet size to be greater than the radio signal PDU to assure the highest quality audio. Other issues such as minimizing system latency, in which case one would

make appropriate tradeoffs to increase the update rate, could influence the optimization of the DSI stream. It should be noted that the user should verify the streams are properly configured prior to starting the testing. In addition, if there is a disruption in the DSI services, which occurred several times during our testing, the streams should be re-verified upon restoration of service.

3.1.1.2 LWTB QS Interoperability

The objective of the LWTB QS interoperability effort was to integrate two (2) QS Modules, one (1) CCTT AAR/Stealth and one (1) CCTT Simulation Manager into the LWTB. A CCTT Maintenance Console was selected as the simulation manager. A contractor provided facility power modifications necessary to install the modules. A means of physically linking the FDDI LAN of the CCTT Modules with the existing LAN at the LWTB was addressed by the network upgrade.

An LWTB Interoperability Test Plan CDRL AB01 number ADST-II-003R-9600302-B for the CDF Upgrade Delivery Order was written, submitted, and approved by STRICOM. The actual testing took place in July 1997. The Interoperability Test Report may be found in Appendix E.

3.1.1.2.1 LWTB QS Interoperability: System/Test Description

The LWTB network installation was completed in July 1997. The GFE CCTT M1A1 and M2M3 modules were installed in May 1997 and ready for integration in June 1997. The CCTT Maintenance Console (MC) purchased by the CDF Upgrade DO was installed and operational in July 1997. The AAR/Stealth purchased by the CDF Upgrade DO was operational in July 1997.

In order to operate the CCTT assets with other DIS devices at the LWTB, the CCTT devices were changed to operate in broadcast mode rather than multicast mode as required by the CCTT program in training environments. In addition, PDU concatenation was turned off for compatibility with DIS devices that do not support PDU concatenation. The change is in the file "start_mm.sh" in the "application/mm/environment/script_files" directory path where multicast is commented out and PDU concatenation is commented out. The MC network address for the CDF MC was left identical to the CCTT MC in order to require the least amount of change to the CCTT module configuration.

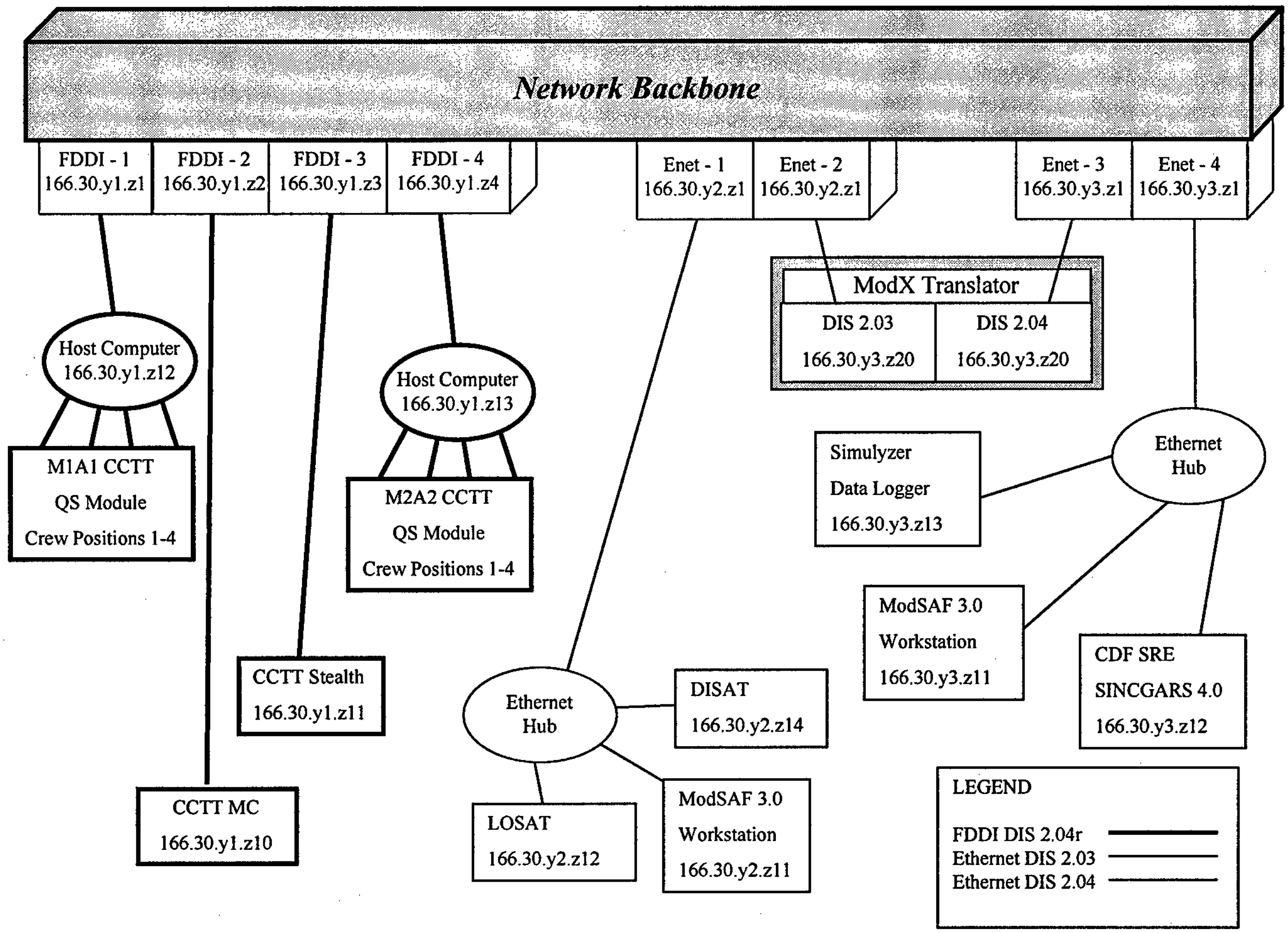

Figure 2 Equipment Used for Testing

The following is a brief description of each piece of equipment used for testing (see Figure 2).

- ModSAF - ModSAF is used to generate the friendly and opposition forces used to make up an exercise. US and USSR entities were used in both ground vehicle and air configurations. The scenarios and locations of the entities are discussed in the test plan. A ModSAF entity is also required for a stand-alone SINCGARS radio to attach to in order to be a part of the exercise.
- M1A1 - The CCTT M1A1 Abrams tank provides training for four positions: commander, gunner, loader, and driver.
- M2M3 - The CCTT M2M3 Bradley fighting vehicle provides training for six positions: commander, gunner, loader, driver, and 2 infantry positions.
- MC - The Maintenance Console provides a means to initialize and position each CCTT module within the battlefield environment. The MC is also used to prepare an exercise scenario including weather conditions, supplies, orientation, and initial position of each vehicle.

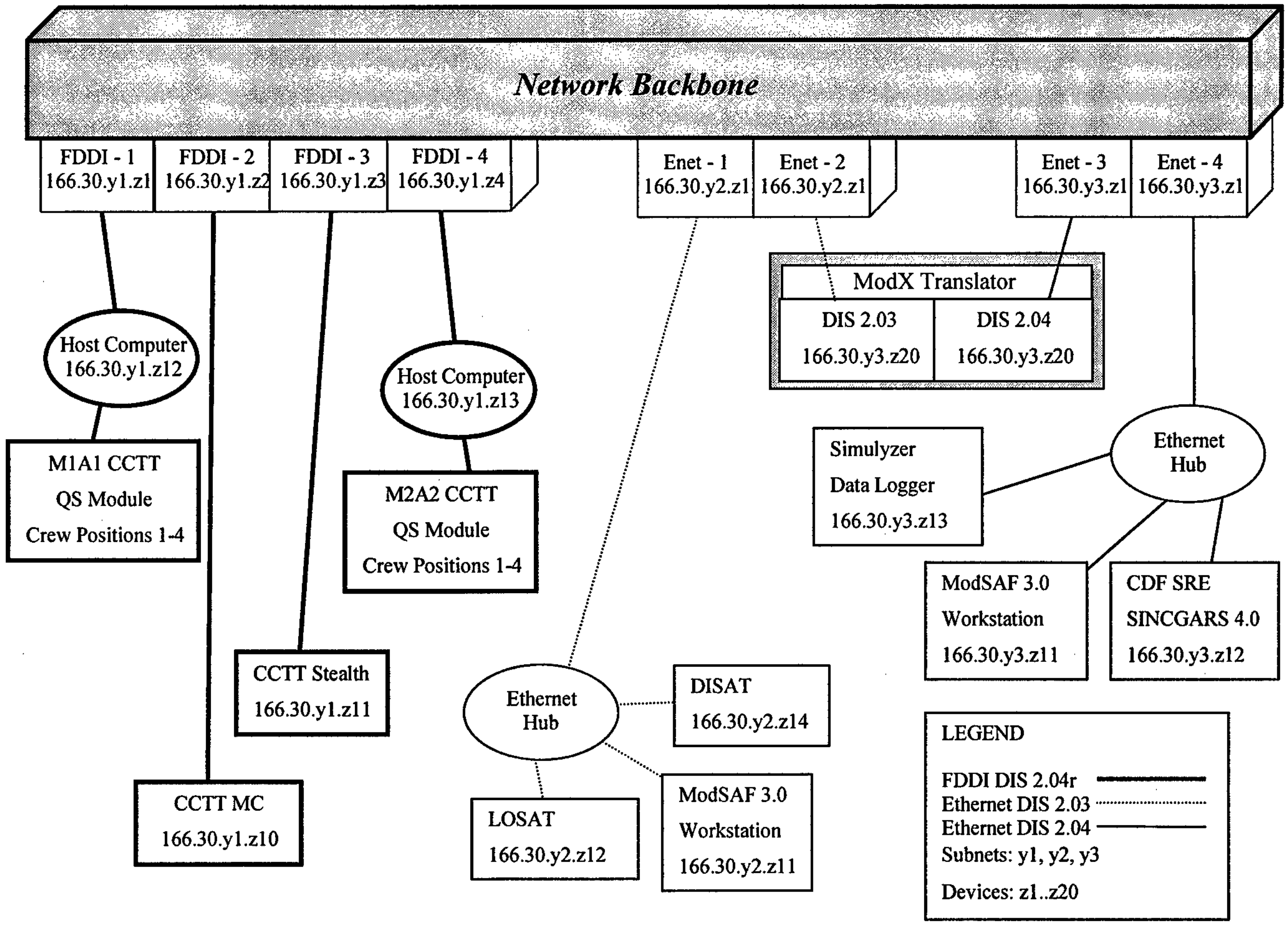

Figure 3 LWTB Test Configuration

- CCTT AAR/Stealth - The AAR/Stealth provides a means for individuals outside the simulators to observe the battlefield scene as well as a PVD representation of the battle. The imagery is generated by an Evans and Sutherland 3000 series image generator and displayed on three 26-inch monitors.
- MOD-X - The MOD-X is a DIS protocol translator allowing DIS 2.03 devices to interoperate with DIS 2.04 devices and vice versa.
- LOSAT - The DIS 2.03 simulator used for interoperability at the LWTB was the LOSAT (Line-Of-Sight Anti-Tank) vehicle. LOSAT was in the HMMWV configuration requiring only a driver and gunner.
- DISAT/Logger - The DISAT (DIS Analysis Tool) /Logger provides the means to record PDU traffic during the exercise for analysis when the exercise is completed.
- SINCGARS - The SINCGARS allowed each device and TOC (Tactical Operations Center) to communicate with one another during the testing. The CCTT M1A1 devices use CVC (Combat Vehicle Crewman) headsets and a SINCGARS interfaced to the PIE (Programmable Interface Electronics). The stand alone SINCGARS were tethered to ModSAF entities to establish battlefield positions and could be operated as either an SRM (SINCGARS radio model) on an SGI Indy platform GUI or as a SINCGARS Radio Emulator (SRE) which is a simulated radio

hardware unit interfaced to an SGI Indy.

Testing was conducted in July 1997. See Appendix E for a detailed description of the testing environment and the test results.

3.1.1.3 OSF QS Interoperability

The objective of the OSF QS Interoperability Test was to integrate two (2) GFE QS CPH Modules into the OSF and procure and integrate one (1) CCTT AAR/Stealth one (1) CCTT Maintenance Console (MC) into the OSF. A means of physically linking the FDDI LAN of the CCTT Modules with the existing LAN at the OSF was also addressed.

An OSF Interoperability Test Plan CDRL AB01 Number ADST-II-003R-9600290-A for the CDF Upgrade Delivery Order was written, submitted, and approved by STRICOM. The actual testing took place in May 1997 and also in July 1997. The Test Report is included in Appendix C.

3.1.1.3.1 OSF QS Interoperability: System/Test Description

The OSF network installation was completed in January 1997. The GFE CCTT M1A1 module was installed in November 1996 and ready for integration and testing by January 1997. The GFE CCTT M2M3 module was installed in May 1997 and ready for integration and testing by June 1997. The CCTT MC purchased by the CDF Upgrade DO was installed and operational in January 1997. The AAR/Stealth purchased by the CDF Upgrade DO was operational in February 1997.

In order to operate the CCTT assets at the OSF, the CCTT devices were changed to operate in broadcast mode rather than multicast mode as required by the CCTT program in training environments. In addition, PDU concatenation was turned off for compatibility with DIS devices that do not support PDU concatenation. Finally, the IP addresses of the devices were changed to be compatible with the IP addresses available at the OSF. The configuration changes were made to the file "start_mm.sh" in the "application/mm/environment/script_files" directory path where multicast is commented out and PDU concatenation is commented out. The IP address changes are more involved. Support was received from the CCTT Program to build the necessary data files to assign new IP addresses to the OSF CCTT devices.

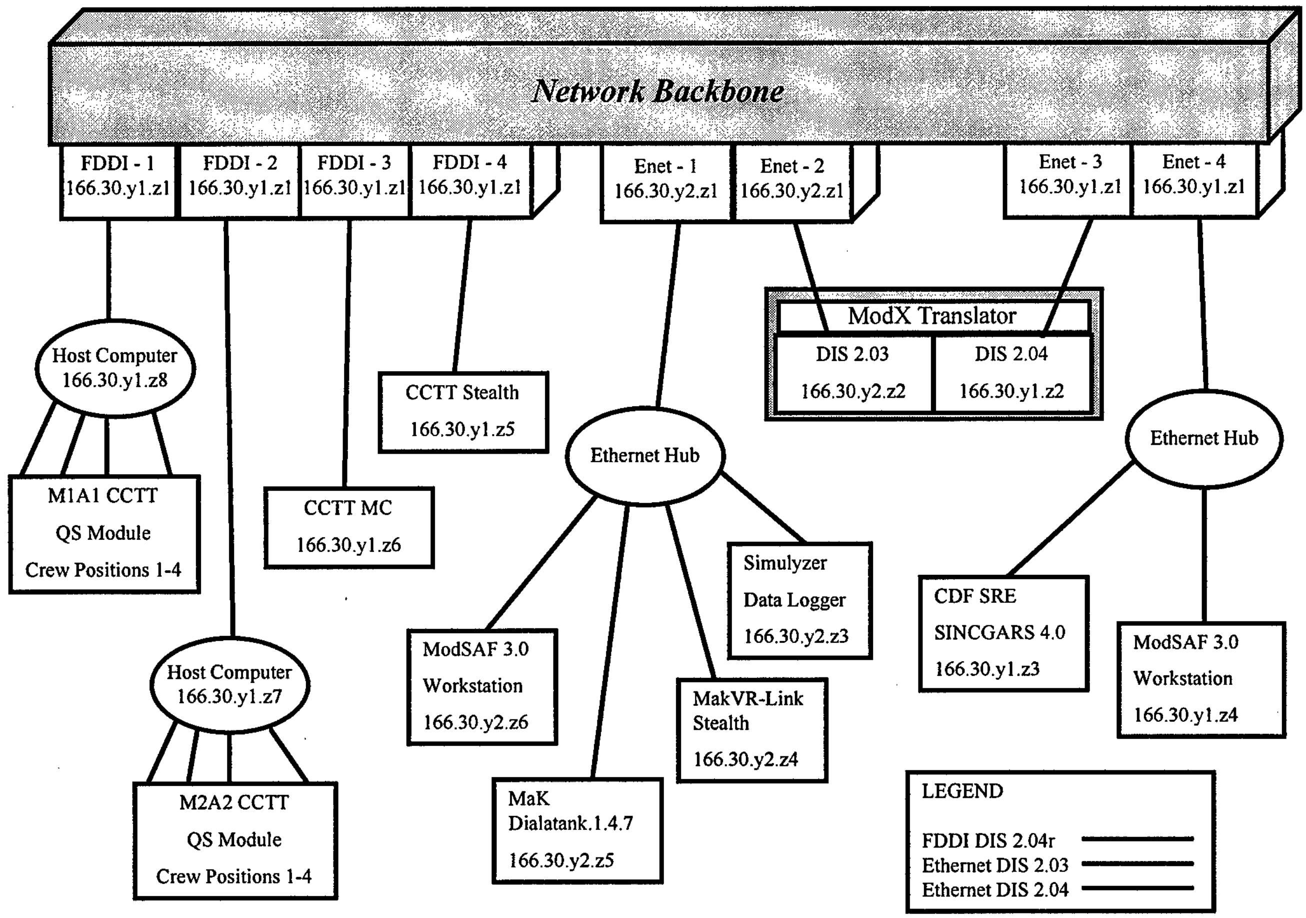

Figure 4 Equipment Used for Testing

The following is a brief description of each piece of equipment used for testing (see Figure 4).

- ModSAF - ModSAF is used to generate the friendly and opposition forces used to make up an exercise. US and former USSR entities were used in both ground vehicle and air configurations. The scenarios and locations of the entities are discussed in the test plan. A ModSAF entity is also required for a stand-alone SINCGARS radio to attach to in order to be a part of the exercise.
- M1A1 - The CCTT M1A1 Abrams tank provides training for four positions: commander, gunner, loader, and driver.
- M2M3 - The CCTT M2M3 Bradley fighting vehicle provides training for six positions: commander, gunner, loader, driver, and 2 infantry positions.

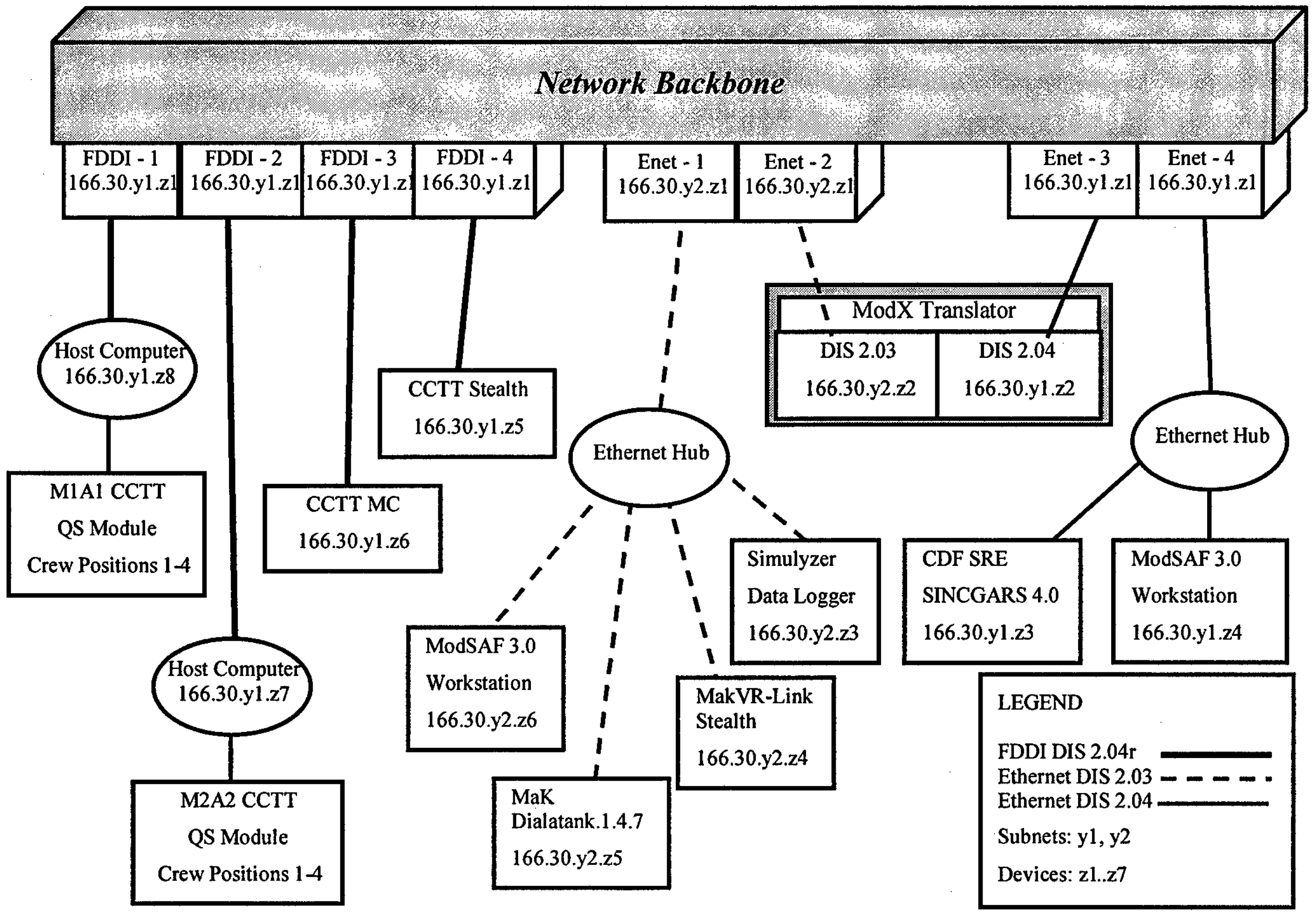

Figure 5 OSF Test Configuration

- MC - The Maintenance Console provides a means to initialize and position each CCTT module within the battlefield environment. The MC is also used to prepare an exercise scenario including weather conditions, supplies, orientation, and initial position of each vehicle.
- CCTT AAR/Stealth - The Stealth provides a means for individuals outside the simulators to observe the battlefield scene as well as a PVD representation of the battle. The imagery is generated by an Evans and Sutherland 3000 series image generator (configured for CCTT) and displayed on three 26-inch monitors.
- MOD-X - The MOD-X is a DIS protocol translator allowing DIS 2.03 devices to interoperate with DIS 2.04 devices and vice versa.
- MäK Motors - The DIS 2.03 simulator used for the OSF testing was the MäK dial-a-tank desktop simulator. The dial-a-tank consists of controls to move it through the battlefield and a stealth device to observe out-the-window imagery. This simulator allowed testing the MOD-X and OSF configuration before proceeding on to the MWTB and LWTB testing.
- DISAT/Logger - The DISAT (DIS Analysis Tool) /Logger provides the means to record PDU traffic during the exercise for analysis when the exercise is completed.
- SINCGARS - The SINCGARS allowed each device and TOC to communicate with one another during the testing. The CCTT M1A1 devices use CVC (Combat Vehicle Crewman) headsets and a SINCGARS interfaced to the PIE. The stand alone SINCGARS were tethered to ModSAF

entities to establish battlefield positions and could be operated as either an SRM (SINCGARS radio model) on an Indy platform GUI or as an SRE which is a simulated radio hardware unit interfaced to an Indy.

Testing was conducted in May 1997 using the M1A1 to interoperate with the other systems excluding the M2M3 and testing was repeated in July 1997 using the M2M3 with all of the other systems. See Appendix C for a detailed description of the testing environment and test results.

~~3.1.1.4ModIOS~~

~~As a result of the integration and testing of the CCTT modules, it became clear that the CCTT MC/MCC was not a good candidate as a general purpose exercise control station when non-CCTT modules were being used. A feasibility analysis study was performed by ADST II DO 80 (CDF 98) and the Motorola ModIOS tool was selected to be the standard control station for the CDFs. Discussion of this tool may be found in the DO 80 final report (ADST-II-CDRL-CDF98-9900253). As part of DO 13, five full licenses for the Motorola ModIOS tool were procured with the necessary hardware. The ModIOS licenses were distributed as follows: 2 AVTB, 1 LWTB, 1 MWTB and 1 OSF. The licenses included the exercise controller, visual stealth, DIS radio, DIS Datalogger, and After Action Review. The hardware consisted of Pentium III, dual 500Mhz processor, Dell 410 Precision Workstations.~~

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Quantity~~Quantity~~	Item~~Item~~
Vendor~~Vendor~~	Dell Computers~~Dell Computers~~
CPU~~CPU~~	Pentium III 500Mhz~~Pentium III 500Mhz~~
2nd CPU~~2nd CPU~~	Pentium III 500Mhz~~Pentium III 500Mhz~~
Memory~~Memory~~	256Mb ECC RAM (1 DIMM)~~256Mb ECC RAM (1 DIMM)~~
Disk~~Disk~~	9Gb Ultra2/WideSCSI drive(10,000RPM)~~9Gb Ultra2/WideSCSI drive(10,000RPM)~~
CDROM~~CD ROM~~	CDROM 14/32x SCSI~~CDROM 14/32x SCSI~~
Sound~~Sound~~	Altec Lansing sound system~~Altec Lansing sound system~~
Video~~Video~~	Diamond Permedia 2, 8Mb AGP Graphics Card~~Diamond~~

	~~Permedia 2, 8Mb AGP Graphics Card~~
Monitor~~Monitor~~	Trinitron UltraScan 1600HS 21" Monitor~~Trinitron UltraScan 1600HS 21" Monitor~~
Mouse/Key ~~Mouse/Key~~	Logitech 3 Button mouse & Keyboard~~Logitech 3 Button mouse & Keyboard~~
Network~~Network~~	10Mbs Ethernet ~~10Mbs Ethernet~~
OS~~OS~~	Windows NT 4.0 (SP 4)~~Windows NT 4.0 (SP 4)~~
Service~~Service~~	3Years Next Business Day, On-site Service~~3Years Next Business Day, On-site Service~~
Option 1~~Option 1~~	Upgrade: Additional 256Mb RAM~~Upgrade: Additional 256Mb RAM~~
Option 2~~Option 2~~	Upgrade: 3D Blaster Riva TNT2 32Mb AGP bus Graphics Card~~Upgrade: 3D Blaster Riva TNT2 32Mb AGP bus Graphics Card~~

Table 1 ModIOS Systems

3.1.2 CCTT Quick Start Development Tool

The quick start development tool, the Trainer Software Support Environment (TSSE), provides the development environment for long term maintenance of the CCTT software. The TSSE is required to maintain the CCTT software design, test documentation, and CCTT source code. The TSSE is required to create deliverable CCTT software, in the required format and media, from CCTT source code. The ADST II TSSE is a single user configuration of the CCTT TSSE.

The TSSE consists of COTS hardware and software necessary for the maintenance of the delivered CCTT software and documentation. These items were procured to provide the capability to modify CCTT's configuration to support future ADST II experiments.

The TSSE hardware is listed in Table 2.

Quantity	Hardware Item
2	FMMLMCCTT-10 / Netview 8000 Host Computer: (MC) with: Video Graphics Adapter - 128K RAM, 4G Hard Drive, CD ROM (Minimum 12X), 1.44M 3.5" Floppy , Interfaces: 2 S, 1 P, 1 SCSI-2, Mouse, keyboard, 100 Mb Ethernet Adapter
2	122056 Model RNS 2200-FSM SAS Dual Attached FDDI Adapter for PCI
1	Diamond Scan 20H 20" Monitor
1	DLT 4700 / Tape Mini Library
1	UPS Smart UPS SNMP
1	PowerMac (150 Mhz, 604) width 17" 1024 x 1280 Display, CD ROM (min 8x), Ethernet Adapter (10Mb), Math Co- processor, MIDI Interface, E111 with RS-422, 32MB, 1Gb
1	Pentium PC Pro 166 Mhz, 32MB RAM, 2 GB SCSI disk, Ethernet (10 Mb) Adapter, 17"1024x1280 Display, CD ROM (8x min), Windows NT 4.0

1	HP Shure STOR CD Writer 6x/2x

Table 2 TSSE Hardware

The TSSE Software is listed in Table 3.

Quantity	Software Item
2	AIX V.4.2 Operating System with Media & Documentation
2	AIX Windows Environment 6000 (GUI)
1	C++ Compiler for AIX 4.2 License and Media
1	FORTRAN Compiler for AIX 4.2 License and Media
1	Power Ada Development Environment, Power Ada Debugger and Aprobe (for AIX 4.2) Single User License
1	VADS Ada Compiler for NT 4.0
1	AdaMotif for AIX 4.2
1	BuilderXcessory
0	Razor (Configuration Management)
0	RTM (requirements management)
0	Amadeus (Metrics)
0	McCabe Reengineering
1	Interleaf 6 for AIX 4.2
1	Windows NT 4.0
1	Win Edit for NT 4.0
1	Sound Designer II
1	INFINITY DSP Looping Tool

Table 3 TSSE Software

Software listed in Table 4 annotated with a quantity of '0' are items that were the subject of a trade study by the CCTT program that was not complete at the time this report was written. The software that performs these functions will be purchased as the results of these trade studies are finalized.

In addition to the hardware to support software and documentation our plan had been to provide a database generation system, the E&S EaSiest. As the CDF Upgrade DO project progressed it was agreed at the Integrated Project Team meetings that a different database generation system to serve a broader application for the ADST II program was needed. It was agreed that it was a better to purchase a Multi-Gen database generation system. The hardware and software for this system is listed in Table 4.

Quantity	Item
1	Octane/MX1 with dual R10000, 4MB Texture Memory, 128MB RAM, 4GB Hard Disk, 20" Monitor with following options: Extra 128M RAM Internal 4mm DAT tape (4GB) MIPS Pro C++ Compiler for IRIX 6.2 IRIS Development Option IRIS Performer 2.1 with Manuals/CD ONC3/NFS for IRIX 6.2 IRIS Impressario Server for IRIX 6.2 CD-ROM Update Media for support Support folio for Warranty 1.1 for Octane CoOp Care Extended Warranty for 1 year
1	MIIE-PMOD-FLT-S MultiGen II Pro Hierarchical Realtime Modeler (license and documentation)
1	MIIO-DB2-FLT-S Multi-Gen II Database Builder 2 Bundle (Texture Pro, Terrain Pro, CAT, Culture Pro, Culture Editor, and Batch Option)
1	ModSAF CTDB Import/ Export Option for CTDB Versions 3 and 5
1	MIIO-SIF-FLT-S Multi-Gen SIF Option (Input Only, Gridded Terrain)
1	S1000 Import Software
1	EWF76 ARC/INFO License and Documentation
1	FS2 Color Scanner by Ricoh with PhotoShop
1	34480 - 3448S1121111 Calcomp Drawing Board 36"x48" .005" accuracy with Manual Drawing Board III Base
1	VistaWorks Maintenance Contract
1~~1~~	9 GB Disk Drive~~9 GB Disk Drive~~
1~~1~~	1GB Memory Expansion ~~1GB Memory Expansion~~

Table 4 Database Generation System Hardware and Software

3.1.3 Rotary Wing Aircraft (RWA) Simulator Upgrade

The AVTB has 8 RWA SIMNET simulators that can be configured for a variety of helicopter types (although two simulators have the capability of being configured as Fixed Wing Aircraft). These simulators have been upgraded to use MetaVR ChannelSurfer Image Generators. Delivery orders have upgraded the RWA monitors, cockpit display, and radios.

The CDF Upgrade DO continued to upgrade the RWAs by providing new rear projection displays and cockpit enclosures made of an opaque tent material covering a simple frame. A ventilator was added to the enclosure to allow heated air to vent out the top of the enclosure. The rear projection displays are described in FAS ADST-II-CDRL-CDF98-9900004. Communications upgrades are described under Communication Upgrades.

Support was also provided for an investigation into a low-cost approach to upgrading the RWA IG by

procuring a prototype 6 channel PC-based IG. This replaced the original plan, which called for procuring upgrades for the GT-111 texture memory. The hardware for the replacement of the GT-111s was procured under the CDF Upgrade, CLIN 13.

The replacement IG is a MetaVR ChannelSurfer system shown in Figure 6. The system is composed of 6 MetaVR VRSG (Virtual Reality Scene Generators), a host and an enclosure with power supply. The IG supports 5 visual and one sensor channel as a replacement for the GT-111. The integration and test of this system will be performed under the CDF98 Upgrade DO.

The Simulation Host was moved from a single board computer that was part of the GT-111 to a PC. The PC was purchased as part of the rack mount system from MetaVR as depicted in figure 6. The port of the Host software is described in the Version Description Document (VDD) ADST-II-CDRL-CDF-9800305.

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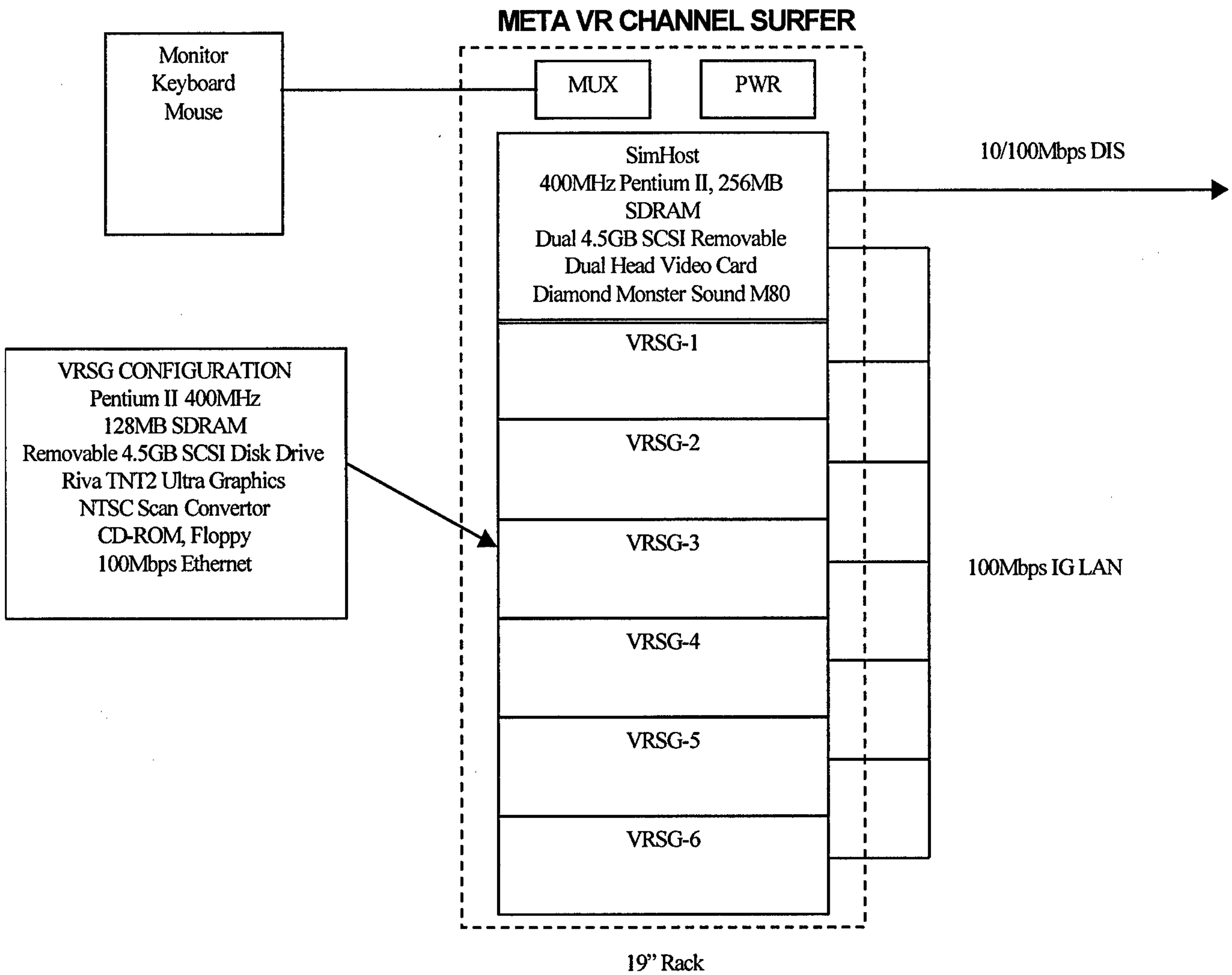

Figure 6 MetaVR Channel Surfer

Quantity	Description
8	**Simulation Host** Intel Pentium-II 400MHz Processor with 512K L2 Cache Asus P2B-DS Dual Pentium-II ATX Motherboard 256MB of PC-100 SDRAM PCI Appian Jeronimo J2 Dual Support Video Card 2 Seagate Cheetah 4.5GB Ultra-2 wide SCSI Hard Drive

	1.44M HD Floppy Drive Toshiba 32X SCSI CD ROM Drive 2 10/100 EtherLink III Network Adapter Card Diamond Monster Sound M80 PCI Card Microsoft Windows 95 v2.5 Iomega Internal SCSI 100M Zip Drive
48	**Visual Channels** Intel Pentium-II 400MHz Processor with 512K L2 Cache Asus P2B-DS Dual Pentium-II ATX Motherboard 128MB of PC-100 SDRAM AGP Riva TNT2 Ultra Video Accelerator Card Seagate Cheetah 4.5GB Ultra-2 wide SCSI Hard Drive 1.44M HD Floppy Drive Toshiba 32X SCSI CD ROM Drive 10/100 EtherLink III Network Adapter Card Microsoft Windows 95 v2.5
8	**Cabinet Hardware** Integrated Keyboard/Mouse Drawer with Keyboard and Trackball 3COM 3C250C-TX12 12-Port 100Base-TX Hub 12 Way Keyboard/Mouse/Monitor Switch Box w/Cables APC Smart-UPS 3000RM Power Backup 17" Rackmount SVGA Monitor
26	**Display Unit** Proxima DP6810 LCD Projector Display Enclosure Mirrors Display Screen
8	**Simulator Enclosure** Frame work and Covers

Table 5 AVTB Hardware

3.2 Site Infrastructure Upgrades

3.2.1 Network Upgrades

This section discusses the local area network (LAN) upgrades implemented at the ADST II CDFs as part of the CDF Upgrade Delivery Order. This work involved the addition of state-of-the-art switched Ethernet and Fiber Distributed Data Interface (FDDI) network backbones and Virtual LANs (VLANs). The upgrade is needed in the near term to support the addition of new CCTT (Close Combat Tactical Trainer) and BLRSI (Battle Lab Reconfigurable Simulator Initiative) simulators, as well as allowing the flexibility to add other devices for the overall ADST II mission.

Background

The next generation of simulators such as CCTT and BLRSI devices requires a FDDI network connection. (Please refer to the respective simulator program for a discussion of the merits of FDDI versus other network technologies.) FDDI networks run at 100 Megabits per second (Mbps) and typically use optical fiber for connectivity although there is an unshielded twisted pair (UTP) configuration. FDDI and other high-speed network technology will enhance the CDFs capability to fully simulate weapons systems including sensor models, weapons models, communication, and battlefield representation. At training sites when all devices are FDDI, a homogeneous FDDI network may be used and the network may be assembled using FDDI concentrators that bridge (i.e. combine) all network traffic together into one logical network. The CDF networks require a different solution.

Networking at the CDFs requires a heterogeneous solution because of legacy equipment and the nature of a development environment. Existing devices use 10 Mbps Ethernet (either the original baseband or 10BaseT). To assemble an experiment's network, the Ethernet transceiver cables are concentrated using a combination of network hubs or multiport transceivers and Ethernet backbone cable as the transmission medium. Each experiment's network is independent and isolated so all broadcast data (the communication method used for the DIS protocol) is only sent to assets assigned to the experiment and connected to the network. All network configurations are done manually through physical connections.

When FDDI and Ethernet simulators are combined in an experiment, the network packet sizes must be made compatible and there must be a device that allows the two networks to interoperate. A LAN switch provides this function. FDDI and Ethernet network segments are connected to "ports" on the LAN switch. The switch manages the flow of data packets between the ports and does the necessary protocol and packet conversions. LAN switches are efficient and have other very useful features such as separating networks into virtual LANs.

LAN switches can separate the attached network segments into broadcast domains or Virtual LANs (VLANs). Using VLANs, the network traffic on one VLAN is not sent to devices on another VLAN (as is the case when all devices are bridged on a common network). Therefore, one LAN switch can be used for multiple VLANs keeping the networks completely separated. (However, security requirements may restrict the use of a LAN switch to one network.)

The FORE Systems PowerHub 7000 LAN switch, selected to upgrade the CDFs, uses a shared memory architecture and high speed backplane allowing data to be sent to many sources from one memory location, increasing the overall throughput of the system. The modular design supports maintainability and upgradeability.

Virtual LANs

The introduction of the Virtual LAN (VLAN) to the CDF DIS environment has many benefits in flexible network configuration and increased effective bandwidth for multiple experiments. Virtual LANs create logical workgroups, regardless of the end users physical location on the network, optimize bandwidth by managing traffic flow within the logical workgroups and span multiple workgroups using PowerHubs connected via Ethernet, Fast Ethernet, FDDI or ATM. They restrict all network traffic, including broadcasts, to workgroup boundaries. The VLAN will allow network administrators to create overlapping workgroups, allowing stations to be members of more than one group at the same time and easily configure and re-configure networks quickly without physical changes.

The applicability of VLANs can be seen in the following example. When hosts are networked in a DIS experiment, each host broadcasts its DIS network traffic (called PDUs) on the network for each player to see. All receivers on the network see every transmission (See Figure 7). This results in decreased performance as the receivers have to process unrelated traffic.

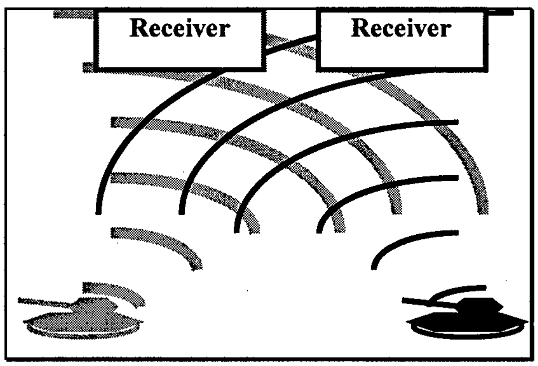

Figure 7 Legacy Physical LAN Network Traffic

In Figure 7, all network traffic from different experiments is broadcast onto the same LAN. Each host receives all network traffic and must process this data to find the information unique to its exercise or experiment. This reduces the quality of simulation, the total network bandwidth and the host CPU process time available to DIS applications.

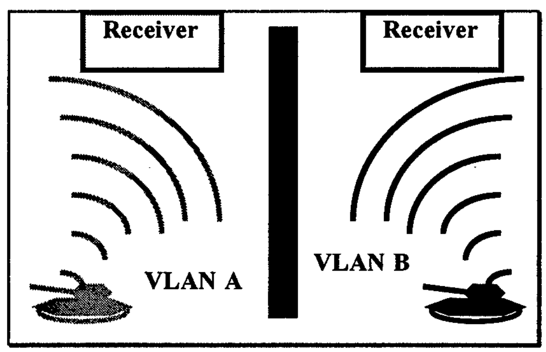

Figure 8 Upgraded VLAN Network Traffic

Figure 8 depicts the case with experiments isolated on VLANs. The receivers on the network see only the transmissions assigned to their VLAN. This results in increased performance as the receivers only have to process the desired information. This separation is done through the logical configuration of the LAN switch without physically disconnecting the networks.

Multiport LAN switches provide VLANs for flexible configurations without extremely complex setup requirements. Each host computer on the system connects to a segment on the LAN switch. Multiple hosts may share a segment by using a repeater hub with multiple ports, which all use the same network segment as the hub.

In the synthetic environment scenario with multiple experiments, VLANs improve host computer efficiency by isolating assets assigned to a particular experiment and passing them only their network traffic. Multiple experiments therefore operate independently of each other. The flexibility of LAN switches also allows assets to be assigned to more than one VLAN simultaneously as in the case of administrative assets and other critical resources (which might be shared periodically). This can be accomplished without physically reconfiguring the network.

LAN switches have the ability to distribute a VLAN between switches. This capability means that if an asset is attached to one LAN switch it can be configured to be a member of a VLAN on a different LAN switch. The connection between the two switches forms a network backbone which is shared by all the VLANs and where all the network traffic is routed to only those assets on the appropriate VLAN. It should be noted that LAN switches do not necessarily replace the need for high-speed network routers that manage WAN and multiple network paths.

LAN Infrastructure

The capabilities of the LAN switch leads to the notion of a semi-permanent network infrastructure at each CDF. First, fiber cable interconnects the network stations that house the LAN switches. The fiber provides backbone connections for the switches. Second, simulation assets are connected to the LAN switch whose configuration defines the asset's VLAN membership. The asset can then be moved to another VLAN (experiment) by a software configuration change rather than modifying the network cabling. Finally, a series of patch panels allow the asset to be physically connected to different VLANs and the backbone as necessary to support the particular experiment. This flexibility of the network infrastructure provides support for multiple classified and unclassified experiments of various sizes.

The CDF network upgrade is designed to prepare for future requirements and accommodate diverse requirements for resources. The fiber backbone can support FDDI, Ethernet over fiber or ATM. The LAN switches can be expanded to add additional FDDI or Ethernet ports and options are available that support the new 100Mbps Ethernet and to connect to ATM networks. To maximize reliability, the LAN switches have redundant power supplies.

LAN Installation

The LAN installation occurred in three steps. First, the cable plant was installed, then the network equipment was configured and tested, and finally, the local field engineers were trained.

Locations for network equipment were selected based on the requirements at each CDF. Each network station included equipment racks with the PowerHub LAN switches, patch panels, and ancillary equipment. Typically, 2 network stations were placed in the computer room (one for unclassified use only, one for unclassified or classified use.) Network stations were also placed in each major high bay. A fiber backbone was then installed to connect each station. This was typically configured in a ring of two 24-fiber cables that provided direct connectivity between any two network stations. Backbone connections were configured with "SC" fiber connectors for durability and ease-of-use.

Within the high bay, network drops from each network station were installed for Ethernet and FDDI. Each Ethernet drop had 12 Category 5 RJ-45 connections for 10BaseT networks. The FDDI drop had 12 FDDI connections. Each site received ten ethernet and FDDI network zones.

PowerHub 7000 (typ. 4 per site) **Dual FDDI** **10BaseT** **FDDI concentrators** **Redundant Power Supplies** **Foreview network management software**
Cabletron SeHi 10BaseT hubs
TP-FOT2 Ethernet to fiber transceivers

Racks, mounting hardware, patch panels, patch cords
Network backbone - 24 fiber cable x 2 cables in ring
Ethernet and FDDI zone cabling
Network Sniffer for 10BaseT and FDDI
Test and installation tools

Table 6 LAN Infrastructure Major Items

Two additional connections were added to the original network design. At the MWTB, fiber was installed to the Training Site and to the TBBVB (TRADOC Brigade and Below Virtual Battlefield). These connections allow connections to the CCTT simulators in the Training Site and allow the connection of the DSI network to simulators in the TBBVB. At the LWTB, the new Light Digital Tactical Operations Center (LDTOC) was connected to the network so it could share the DSI connection and be able to interoperate with other LWTB assets.

Each site received a complement of network test and installation tools. The primary debugging tool is the Network General "Sniffer" which is used to debug connectivity, addressing, protocol and hardware problems on a network. Interfaces for 10BaseT Ethernet and FDDI were included. Test tools included wiring trace tools, connector installation tools, punch-down tools, intercom over fiber talk set and fiber test and repair tools. Fiber test equipment (such as the powerloss meter) and repair material was located at the OSF because it was not expected to be heavily used and can be shipped quickly to any site. This equipment is primarily for major backbone cable installation, which is expected to occur infrequently. Frequently used patch cords can be tested by substitution and if inoperable, should be discarded or sent to the OSF for repair.

One Fore Systems basic training course was held in Orlando and was attended by several engineers. An engineer from the OSF performed network training at the CDFs. The instruction was separated into two segments, basic and advanced. The engineer went to each site and worked with the local FEs going over the network basic operation as the network was tested and configured. As the sites began using the new network, he worked with them on configuration problems, introducing them to advanced features as needed. The training material was collected in a series of web pages located on the ADST II Intranet web server.

3.2.2 ModSAF Hardware Upgrades

The ADST II ModSAF DO performed a trade study to select the optimum platform for ModSAF. The result of the study indicated that the DEC Alpha running DEC UNIX and the Intel Pentium Pro running Linux were the optimal choices for ModSAF platforms. The CDF Upgrade DO purchased these platforms and fielded them with ModSAF 3.0. Four DEC Alpha 333MHz were provided as GFE so only an additional four DEC Alpha 500MHz workstations were procured. Large internal disk drives were not considered necessary on the DEC Alphas because they were to be configured with the removable, external disk drives also being procured. External tape units and disk drives were determined to be more advantageous than internal devices because external devices may be easily moved between machines. Table 7 describes the ModSAF hardware purchased by the CDF Upgrade DO.

Quantity	Item
2 each LWTB, MWTB	DEC Alpha 500MHz, 128MB RAM, CD, Floppy, 2G Hard Disk 21" Color Monitor, C Compiler, Ethernet, FDDI, DEC UNIX 4.0

14 AVTB 10 LWTB 11 MWTB	Pentium Pro 200 MHz, 128MB RAM, CD, Floppy, 4G removable Hard Disk, Linux, Accelerated-X, Motif, Ethernet

Table 7 ModSAF Hardware

In addition to the new ModSAF machines, additional memory was procured for the existing SGI Indy ModSAF machines at the AVTB.

3.2.3 Datalogger Hardware

Datalogger workstations were procured for each site. The ADST I Datalogger software was ported to the Solaris 2.5 operating system to be the primary application. The same workstation was selected for both the Datalogger and the DIS Analysis Tool to provide more flexibility and backup for experiments. The SUN Ultra 170 platform was chosen for price performance and ease of porting. Table 8 describes the Datalogger hardware configuration as purchased by the CDF Upgrade DO.

Quantity	Item
1 AVTB 1 LWTB 2 MWTB	SUN Ultra 170, 128MB RAM, CD ROM, Floppy, 20" Color Monitor, 2nd SCSI, C, C++, Laser Jet Printer, Assorted External Disk Drives, Solaris 2.5, Ethernet, FDDI

Table 8 Data Logger Systems

3.2.4 A2C2S/AVTOC Hardware

The CDF Upgrade DO provided infrastructure to run the Army Airborne Command and Control System (A2C2S) and the Aviation Tactical Operations Center (AVTOC) C4I workstations. Ten Sun SPARC 20 Model 71 workstations were procured to support the Digital Training eXercise (DTX) and future C4I DOs. The configuration included a 75MHz processor, 32M Ram, 2.1G Hard Disk, and a 20" Color Monitor with 1280X1024 Resolution.

3.2.5 Communication Upgrades

The CDF Upgrade DO procured a suite of radio simulator servers from Advanced Simulation Technologies, Inc. (ASTi) for the JCSAR and DTX DOs. These servers provide up to 16 radio simulations each. The radios may be configured for a variety of radio types (UHF, VHF, etc.). Handheld terminals were also procured to provide the user interface to select frequencies that each radio operator could transmit and receive on.

The CDF Upgrade DO performed a trade study as part of the rehost effort (see 3.5.2) to select the best host platform for SINGARS software. The result of this study was to select a low-cost SGI Indy platform to be the host, as no PC-based (PCI Bus) sound cards were available that met the multi-channel audio requirements of the SINCGARS. Ten new SINCGARS faceplates were also procured.

A new simulated switch panel was developed for the RWAs to simulate the actual radio switch panels. This panel provides the operator the ability to monitor up to 5 channels and transmit on the internal intercom or on one of 5 radios. The switch panel allows the SINCGARS radio model to be integrated with the ASTi radios so both may be used concurrently. Table 9 defines the communication hardware procured by the CDF Upgrade DO.

Quantity	Item
6 AVTB	ASTi Radio Simulator Servers - Industrial Line, 8 channel DACS with Handheld terminals
14 MWTB	Indy SINCGARS Radio Model (Uses GUI) 133MHz, R4600PC, 8-Bit Color, 32MB, 1.0GB System Disk, 1280x1024, 17" Monitor, IRIX 6.2
4 AVTB 6 LWTB	Indy SINCGARS Radio Emulator (uses SINCGARS faceplate)
29 AVTB	RWA Switch Panels

Table 9 Communication Upgrades

3.2.6 DIS Data Analysis Suites

The Data Collection and Analysis (DCA) toolset allows for the recording and analysis of data collected during DIS training exercises. The DCA Logger records DIS PDUs with time stamps while a DIS exercise is being run. The DCA Analysis system allows the user to generate reports containing data such as shot, hit and kill statistics, intervisibility over time, an engagement timeline, vehicle information, and other data which may be extracted from the data recorded by the DCA logger. The DCA toolset was modified to operate on a SUN SPARC ULTRA, 166 MHZ CPU with 128 Mb RAM running on Solaris 2.5.

The DCA Toolset Software was developed as two separate executables. The first executable contains data analysis software developed at the MWTB and creates ASCII data reduction files.

The second executable contains data analysis software, which uses the BBN COTS product RS/1 and creates data reduction files in RS/1 format. This executable allows greater data reduction capabilities than the MWTB data analysis software and in addition allows graphical representation of the data. RS/1 licenses were procured and furnished to each of the CDFs with a copy of the DIS Data Analysis software. Sites with existing RS/1 licenses received upgrades to the new SUN platforms.

Sites that use the TASC Simulyzer package (AVTB and LWTB) received licenses for the Informix database software. Informix software provides a function similar to the RS/1 package.

Refer to Version Description Document number ADST-II-CDRL-003R-9600485-A for additional information on the SUN5 DCA Toolset. Table 10 details the configuration of the DIS Data Analysis system hardware.

Quantity	Item
1 AVTB 2 LWTB 2 MWTB	SUN Ultra 170, 128MB RAM, CD ROM, Floppy, 20" Color Monitor, 2nd SCSI, C, C++, line printer Assorted External Disk Drives, Solaris 2.5, Ethernet, FDDI RS/1 and/or Informix

Table 10 Data Analysis Suites

3.2.7 T1 Internet Communications

Access to the Internet is vital for operation throughout ADST II. The CDF Upgrade funded an upgrade to the existing network to the CDFs to increase the ADST II Internet access to a full T-1 (1.54 Mbps). Table 11 lists the service and equipment provided to improve Internet communication.

Quantity	Item
1	**Frame/Relay upgrade to 512/768 kbps Private Virtual Circuits (PVCs) to each CDF and a T-1 interface to the Internet.**
7 AVTB 7 LWTB 13 MWTB	**Desktop PCs with ADST II standard software tools**
1 OSF	**Wide body ink-jet plotter**
1 AVTB 1 MWTB 1 OSF	**MetaVR VRSG v2.5, HLA RPR FOM v0.7 and Middleware v1.0, Windows 98, Pentium II Xeon with MMX Technology, 512Mb RAM, 3Dfx VooDoo2 Graphics Card, Adaptec Ultra SCSI Controller, Removeable SCSI drive, SCSI CDROM XM-6401TA, SCSI Zip 100, Monster Sound II MPU-401 Sound Card, 3com 10/100Mbs Ethernet, Space Orb, ViewSonic P815 21" Monitor with 4 port USB bus expander,**

Table 11 Desktop Computing

3.2.8 DIS Stealth Upgrades

The CDF Upgrade DO provided and integrated two (2) DIS-compatible Stealths into the OSF and LWTB for the CCTT simulators. Additional low-end stealths were provided to the AVTB, LWTB and MWTB. The stealths provided were Virtual Reality Scene Generator (VRSG) stealth viewers by MetaVR, which are PC-based, DIS Stealths that are fully correlated with the ModSAF Compact Terrain Database (CTDB). Table 12 shows the stealth systems that were procured.

The MetaVR VRSGs include the following features:GUI Controls:

- ModSAF Interoperability (CTDB correlation) for a big-endian or little-endian ModSAF host
- Save and retrieve named viewpoints from GUI
- Save (auto-named) and cycle through viewpoints through keyboard (S,V)
- Teleportation to an arbitrary location upon database
- GUI-managed entity list and preferred entity list, listing both entity ID and marking text
- GUI-selectable attachment modes (compass, tether, orbit, mimic, track)
- Coordinate displays on 2D overlay help screens given in coordinate system of choice (UTM, LL, or TDB)
- Keyboard controls for the eyepoint
- Orb controls for the eyepoint
- Keyboard controls for the eyepoint

Additional VRSG Capabilities:

- Added 2D overlay text (e.g. eye-point location, heading, terrain elevation, eye-point AGL)

- Entity marking, ID, enumeration, and attachment mode given whenever attach entity changes or attachment mode changes
- Entity enumeration -> model mappings specified by a user-editable ASCII file (UEAF)
- Add/modify sounds for fire/detonations via UEAF
- Edit texture maps for entity models
- Edit texture maps for terrain databases
- Maintain different texture libraries for different terrain databases

Maintain different texture libraries for the same terrain database (switch between OTW, FLIR, Day-TV, NVG type views)

The CCTT AAR/Stealth console consisting of a Netview 8000 host computer, ESIG 3000, 3 RGB 25 inch displays, geoball for flying the eyepoint, 2 Mitsubishi 20 inch monitors for the PVD and the AAR menu, and a dual cartridge 4 mm tape drive. All of the capability of the CCTT AAR/Stealth is used except the radio system and printer hard copy.

The CCTT AAR/Stealths include the following features:

PVD - An orthogonal topographical view of the gaming area is provided that allows zoom.
Visuals - A three-channel visual is provided that is capable of being positioned at any point and orientation on the PVD. Three channel unity magnification and single channel high power sight visualization is provided.
Stealth Eyepoint Control - The eyepoint for the stealth can be positioned using several modes: manual position via mouse or input coordinates, tether to vehicle via mouse, and fly via the six degree of freedom input device.
Record Capability - A 4mm dual tape drive system is provided that allows recording of all entities during an exercise.

The CCTT stealth PVD provides a user-friendly GUI interface that is easy to learn and operate. The interface allows the user to select the view parameters for the PVD. This includes the zoom parameter, which can be selected as a ratio, an increase or decrease to the next size or by selection of an area to be viewed via a dragged box. The interface allows the user to query entities to determine what the vehicle is. Many different options are available to control the use of the stealth including the capability to record or monitor the exercise.

The PVD is updated at 1 hertz to show the location of all network entities on the topographical map. This provides a graphic image of the battle as it evolves. The entities are represented by symbols indicating the type of vehicle and showing their relative positions and bearing. The entity enumeration, ID and marking are also available as well as attaching a user defined text message. Topographic lines of equal elevation are provided as well as key features such as roads and rivers in a very clear manner.

The visual system for the CCTT stealth is a 3 channel ESIG that provides a 15-Hertz update for the viewer. The visual system provides essentially the same imagery as the commander in an armored vehicle simulator would see. The field of view is 30° V x 120° H in the unity day mode, which is the most frequently used visualization choice. In addition, the user can select high power sight mode, which utilizes the center of the 3 channels to display a high power image similar to what is seen in an

actual vehicle. A bearing of the stealth visuals is shown in the center display to help the operator determine orientation. The stealth provides a 6 degree of freedom input device (geoball), for flying the stealth eyepoint. The capability for locking any combination of the degrees of freedom is provided, which is desirable in certain cases to facilitate flying the eyepoint. The stealth eyepoint can also be tethered to any vehicle either to the hull of the vehicle or in an orbit mode. The latter of these modes was found particularly useful.

The CCTT stealth provided a high fidelity stealth capability that was used as the observation center for exercises where the CCTT manned modules were used.

Quantity	Item
1 LWTB 1 OSF	CCTT Stealth, 3 channel, PVD, ESIG 3000, Netview 8000 host, FDDI, Dual 8mm tape drive
5 AVTB	MetaVR VRSG, Pentium Pro, 200 Mhz, Obsidian 3D Fx Graphics Card, 128MB RAM, Windows 95 Operating System
2 LWTB	MetaVR VRSG, Pentium II, 233 MHz, Obsidian 3D Fx Graphics Card, 256MB RAM, Windows 95 Operating System
2 MWTB	MetaVR VRSG, Pentium II, 233 Mhz, Obsidian 3D Fx Graphics Card, 128MB RAM, Windows 95 Operating System

Table 12 Stealth Systems

3.2.9 Tape Backup Drives

Analysis of the requirements for external tape drives indicated that 4mm and 8mm tape drives were required for general use at all sites. Table 13 details the type and quantity of tape drives procured for each site.

Quantity	Item
2 AVTB 2 LWTB 2 MWTB 3 OSF	8mm External SCSI Tape Drive
2 AVTB 2 LWTB 2 MWTB 3 OSF	4mm External SCSI Tape Drive

Table 13 Tape Drives

3.2.10 Compact Disc (CD) Drives

External CD ROMs are necessary to put operating systems on disks after they are declassified or upgraded to new versions of the OS. Additional drives allow more workstations to be configured concurrently improving operational efficiency. The external CD ROMs procured with the Datalogger and DIS Analysis Tool workstations partially met this requirement. Table 14 details the quantities of CD drives procured for each site.

Quantity	Item

3 AVTB 3 LWTB 3 MWTB 2 OSF	External SCSI II CD ROM

Table 14 Compact Disk Drives

3.2.11 Precision Lightweight GPS Receivers (PLGRs)

Deleted.

3.3 Spare Parts

A list of spare parts for the ADST II program was generated by evaluating the existing hardware and the new equipment procured by the CDF Upgrade DO. Ease of replacement, cost and failure rate factors were considered. A spare parts list based on MTBF was obtained for the M1A1 and M2M3 from the CCTT program. The final list was reviewed and adjusted according to experience.

3.4 Hardware and Software Maintenance Contracts

A list of maintenance contracts was generated based on the criticality and potential need for software upgrades. Critical equipment such as the network switches need to be under maintenance to provide access to hardware and software support and timely resolution of problems. General-purpose workstations that run ModSAF, Dataloggers, DISAT or other DIS tools are expected to have a lifetime that will include operating system upgrades. The upgrades may be for maintenance but more likely will be required to support new versions of software.

3.5 CDF Functional Upgrades

3.5.1 Standardized Removable Hard Drives

Requirements for removable hard drives were generated. Purchasing determined the lowest cost provider and several evaluation units were obtained. These units were attached to SUN and SGI workstations to determine that they operated as expected. The result of this evaluation is that a vendor was selected that provides single, dual and quad external drive bays. A standard SCSI II 50-pin interface and a 4GByte drive were selected. The external drives may be connected to any workstation with a SCSI II interface. Workstations with newer 68 pin wide SCSI interfaces may also be supported by using a 50/68-pin SCSI cable. Some degradation in performance would be expected in this configuration but this is not typically a problem in the DIS systems considered.

Another use of these drives is to clean disks that are on systems that have no declassification procedures. The disks from the classified system are connected to a SUN or SGI. The approved declassification procedure is then used to clean the disks. In order for this technique to work, enclosures must support the type of disk being cleaned; either narrow or wide SCSI. The 50 pin units support the narrow disks. Some 68-pin versions were procured to support the wide SCSI units

Generally, single bay enclosures are useful to allow a workstation to operate from an external drive. If the drive is classified, it may be quickly changed with an unclassified drive and the workstation used immediately for other work. The multiple drive bay enclosures are useful for data logging and analysis experiments that require the collection or processing of large amounts of data. Because the drives are removable, classified data may be removed and locked in a safe so that the workstation may be used for other experiments and not be restricted to the classified experiment.

Where possible, workstations were purchased with removable drives (e.g. the ModSAF PCs and the MetaVR stealths.) Table 15 identifies the quantities and types of enclosure by site procured for general use. Four-gigabyte disk drives were procured to populate the enclosures. It is expected that DOs with special security requirements will buy additional disk drives when necessary.

SITE	1 BAY	2 BAY	4 BAY
AVTB	16	4	0
LWTB	4	6	2
MWTB	16	2	0

Table 15 Compact Disk Drives

3.5.2 SINCGARS Rehost

Refer to SINCGARS Version Description Document (VDD) document number ADST-II-CDRL-003R-9600468-B. This VDD contains a functional description of the latest software release of the Single Channel Ground and Air Radio System (SINCGARS) Simulator as prepared for the CDF Upgrade Delivery Order. This document includes a set of build instructions, installation procedures, identification of any known problems, release notes, and any essential data relationships that are part of this software release. This release remains compatible with the DIS 2.03 and DIS 2.04 interfaces

SINCGARS Rehost Summary:

1. Addition of Instructor Voice Channel (IVC) Capability. The software was modified to include IVC capability. This provides clear communication between the instructor and any students he has selected for a conversation. IVC voice will over-ride tactical voice, including the vehicles' intercom systems.
2. The software was rehosted onto an SGI Indy running IRIX 6.2 operating system. This change allows the SINCGARS Simulator to be run on an SGI Indy with either IRIX 5.2 or IRIX 6.2 operating system. This change was implemented to provide ease for future upgrades, since the SGI no longer supports the IRIX 5.2 OS.
3. Modification of the Graphical User Interface (GUI) Faceplate. The SINCGARS faceplate GUI software was modified to ensure compatibility with the current version of SINCGARS. The faceplate GUI can be used in place of the SINCGARS green box. All functions found on the SINCGARS green box are replicated on the faceplate GUI. The audio will be input using a push-to-talk PTT button on the GUI and an SGI Indy microphone. The audio will be heard through the speaker in the SGI Indy.
4. Addition of GUI Executive Rehost to IRIX 6.2 platform. The software was modified to provide a GUI executive. This allows the radio operator to easily modify the data specific to his radio.
5. The CAC2 feature was removed from the SINCGARS Simulator.
6. Allowance for receiving large Fiber Distributed Data Interface (FDDI) network packets. The software was modified to handle large CCTT FDDI network packets. This allows the CDF SINCGARS to process the CCTT SINCGARS Signal PDUs. This change was necessary for compatibility with CCTT.
7. Added Rotary Wing Aircraft (RWA) capability. Added the capability to utilize an ASTi hand-held terminal for SINCGARS control in the RWA.
8. Allowance for variable transmit range and radio power settings. The software was modified to read the power values for the transmitter power switch from a datafile. This allows the radio operator to change the power at which his radio transmits. This change was necessary to allow

the SINCGARS to model different power output settings, since the old model was based on the power output of a ground vehicle SINCGARS. This configuration will allow the SINCGARS to model the low output of a downed pilot (PRC-113) or the Airborne SINCGARS (ARC-201C).

9. Electronic Remote Fill (ERF) problems corrected. A bug in the ERF software was corrected and the radio is now capable of being configured via ERF.
10. The audio incompatibility problem with CCTT was corrected. The CDF SINCGARS is now able to receive audio from and send audio to the CCTT SINCGARS. This was accomplished by changing the method of Continuous Variable Slope Delta (CVSD) encoding implemented in the SINCGARS software model. The problem was the algorithm used in the previous version processed the audio bits from MSB to LSB. The fix processes the bits from LSB to MSB to match the method used in the CCTT software and in the CVSD specification (MIL-STD-188-113 Interoperability and Performance Standards for Analog-to-Digital Conversion Techniques).

4.0 SUMMARY OF CDF UPGRADE INTEROPERABILITY ISSUES

The interoperability testing exposed several CCTT interoperability issues. Among those that have been identified are:

- **Z-axis correlation between Primary 2 and CTDB 7 (ModSAF) terrain database;**
- **few ModSAF entities recognized by CCTT;**
- **CCTT Module is not damaged by ModSAF OPFOR entities and certain ModSAF Entities (BMP) are not damaged by CCTT;**
- **Intercom and Minefield PDU conflict with ModSAF (resolved by ModSAF PTR).**

These issues are discussed in the following together with recommended actions.

4.1 Overview

The requirement for CDF Upgrade to evaluate device interoperability was divided into two major subtasks. The first involved interplay between the new CDF SINCGARS (v 4.1), developed under this DO, and older SINCGARS devices, both stand-alone and vehicle/aircraft configurations. All of the older SINCGARS devices were upgraded with the new software and operated on the SGI 4600 platform. In addition, interoperability between the CDF SINCGARS and the CCTT SINCGARS was evaluated.

The second subtask involved interplay between the CCTT QS Modules (M1A1 and M2M3) and other selected simulators/devices that operated on DIS 2.03 or 2.04 protocols. A special DIS PDU translator (MOD-X) developed under this DO enabled interplay between the DIS 2.03 and 2.04 devices and was a key element for this series of tests.

A total of five series of tests were developed as follows:

- Two SINCGARS interoperability tests conducted on-site at the AVTB and MWTB.
- Three CCTT QS Module interoperability tests. Two conducted on-site at the OSF and LWTB and one conducted as a long haul interoperability test between the OSF and MWTB.

4.2 SINCGARS Interoperability Issues

The MWTB and AVTB SINCGARS on-site tests were successfully conducted with no anomalies observed other than occasional instances of operator error which were attributed to insufficient detail in the test procedures. These situations were corrected and the devices performed as expected. It should be noted that during each test, all SINCGARS radios were operating on the same DIS protocol (DIS 2.03 at MWTB and DIS 2.04 at AVTB). This is significant because during the Long Haul Test

(MWTB-OSF), communications degradation was observed when SINCGARS at MWTB (DIS 2.03) communicated with the CCTT SINCGARS (DIS 2.04) at the OSF, through the MOD-X. The poor audio quality was observed only at the CCTT crew positions.

Additional testing was conducted to verify interoperability between the SINCGARS radios and the ASTi radios at the AVTB. The ASTi model builder software includes a command to specify the CVSD encoding type. The following command description is taken from the ASTi Model Builder Reference Manual. The command is:

DIS:CVSD_Encoding_Type=<Decimal Number>,<Decimal Number>

Where <Decimal Number>=YYY and is in the range 1 through 255.

The command assigns the DIS Signal PDU audio data encoding type number to the two existing CVSD encoding schemes. The first decimal field assigns the encoding type number for the original CECOM SRM CVSD [Note: This refers to the method used in the original ADST SINCGARS SRM] encoding method. The second field assigns the encoding type number for the CCTT SRM CVSD encoding method.

This feature requires the DACS to interoperate with either the CCTT SRM or the original CECOM SRM as these two systems currently use a different CVSD encoding schemes but use the same value of 2 in the Signal PDU encoding type field.

The DACS uses a value of 2 (as specified in the DIS standard) and an arbitrary value of 7 to define and differentiate the second encoding type. 7 is currently an unassigned encoding type number in the DIS standard.

To provide default interoperability with the original CECOM SRM encoding scheme use the following command line:

DIS:CVSD_Encoding_Type = 2,7

To provide default interoperability with the CCTT SRM CVSD encoding scheme, use the following command line:

DIS:CVSD_Encoding_Type = 7,2

The default value is:

DIS:CVSD_Encoding_Type = 2,7

Once the CVSD_Encoding_Type, frequencies and location coordinates are set, the radios will interoperate.

4.3 CCTT Module Interoperability Issues

Issues related to CCTT Module interoperability were divided into the following categories:

- CCTT and ModSAF interplay
- CCTT and CDF SINCGARS interplay
- CCTT and DIS 2.03 Simulator interplay (via MOD-X)
- CDF Interconnectivity via the DSI WAN

Interoperability between individual CCTT Modules was not evaluated. Also, any recorded observations/anomalies which involved components or subsystems of a device (i.e. CCTT Commander's primary sight inoperable, Gunner's Unity Window upside down etc.) were not categorized as interoperability issues.

Terrain Correlation between ModSAF and CCTT

The CCTT modules use geocentric coordinates to determine their positions in the database independent of the terrain. ModSAF also uses geocentric coordinates for vehicle positioning which resulted in very close correlation between the CCTT modules and the ModSAF entities during the CDF upgrade interoperability testing. The error in the X and Y axes was less than 1 meter and the error in the Z axis was less than 3 meters. The Z axis error was greater due to the geocentric to MGRS coordinate transformations being done by ModSAF and/or CCTT.

The terrain surface however is determined by grid posts which have a terrain skin stretched over the posts. The ModSAF database uses a 125 meter grid post spacing and then stretches the terrain over top. CCTT using the ESIG 3000 image generator used a 62.5 meter grid post spacing and stretched the skin in different directions between posts. This resulted in visual errors of road intersections and terrain features. The CCTT terrain is also modified by altering size and shapes of the terrain to improve IG performance and the visual image to the operator.

CCTT module to ModSAF battle damage

There are two conditions for engagement between ModSAF and CCTT

a). ModSAF shoots at a CCTT vehicle or

b). CCTT shoots at a ModSAF vehicle.

For the first situation when ModSAF shoots at a CCTT vehicle ModSAF generates a Fire PDU describing the type of munition, and then ModSAF generates a Detonate PDU. The CCTT vehicle receives the Detonate PDU and using CCTT damage assessment look up tables determines whether the CCTT module suffered no damage, firepower kill, mobility kill, firepower and mobility kill, or catastrophic kill. The CCTT module will then update the Entity State PDU appearance field to define the CCTT vehicle appearance to the DIS network. The problems discovered during the interoperability testing when a CCTT vehicle could not be killed were either the way CCTT defines the Detonate PDU it received from ModSAF or the munition enumeration parameters defined by CCTT. This situation requires further research on the CCTT damage decision algorithms and munition enumerations.

For the second situation when CCTT shoots at a ModSAF entity, CCTT generates a Fire PDU and then a Detonate PDU. ModSAF receives the Detonate PDU and using the vulnerability of the ModSAF target determines whether the ModSAF entity suffered either no damage, fire power kill, mobility kill, firepower and mobility, or catastrophic kill. ModSAF will then update the Entity State PDU appearance field to define the ModSAF entity appearance to the DIS network. The vulnerability of the ModSAF target is affected by many variables. For a ground vehicle shooting at a ModSAF ground vehicle the direct fire vulnerability case applies. The IUA table (standard AMSAA Pk datafile used for most conventional weapons firing at ground targets) contains the probability of kill (Pk) information for typical ground targets firing conventional weapons. The descriptors are range to the target, defilade status, dispersions of the munitions, and the angle of impact of the munitions. Range between CCTT and ModSAF entities is accurate due to using geocentric coordinates for target placement and munitions impact point. Defilade status however is either 50% visually occulted or fully exposed. The correlation of the terrain will have a large effect on visual occulting of the target! The dispersion of the round is based on military data for a given weapon type and will be accurate if the munition enumeration is correct. The angle of impact between the munitions and the target is accurate as long as the target and ModSAF X,Y,and Z axes are correlated. This analysis therefore indicates terrain correlation may be a cause of incorrect damage calculations. This hypothesis needs to be verified with further testing.

Recommendations

Overall, the tests demonstrated that the various devices, running on different models of the NTC terrain database, as well as different operating software/systems and hardware platforms, could interoperate with a fair degree of fidelity and reliability. However, interplay between the systems was negatively impacted/consistently degraded due to several factors. Those factors causing the greatest negative impact to high-fidelity training or experimentation include:

1. Lack of terrain-clamping capability on some devices/simulators, including the CCTT Modules, combined with uncorrelated Z-axis' between the different terrain databases resulted in entities disappearing below ground or floating through the air. The task of target identification/acquisition and engagement, particularly between the manned simulators and ModSAF entities. was not possible when the target was partially or completely below terrain.,

Recommendations: Develop, test and implement automatic terrain clamping of non-CCTT DIS entities. Upgrade all CCTT Image Generators with the new software/hardware.

2. Limited number of common/compatible entity models (vehicles and aircraft) which are available between ModSAF and the manned CCTT simulators, combined with no "default" entity model on some devices. This situation limits the usefulness of the devices to interoperate effectively in support of diverse force-on-force training, exercises or experiments. The visibility of ModSAF entities by CCTT is detailed in Table 16.

Recommendations: Develop, test and implement software model mapping capability for CCTT. This capability would take unrecognized DIS PDUs and map them to a user specified entity mapping table.

3. Inconsistent or incorrect PDU recognition/identification (and subsequent reaction) between ModSAF entities and the manned simulators, to include entity state, appearance, fire, detonation and associated damage/kill (survivability/vulnerability) thresholds. This situation also limits the devices' capability to provide or support high-fidelity training, exercises or experiments.

Recommendations: Verify low level details of DIS 2.04 PDU compatibility in CCTT using the DIS Test Suite Tools. Investigate discrepancies and implement software fixes if necessary.

Interoperability issues between ModSAF and CCTT should be given the highest priority for investigation/resolution because these devices, when operating together, provide great versatility in supporting/enhancing/improving high fidelity training and experimentation. To facilitate this, additional controlled testing is recommended to identify and document other correlation, performance and/or fidelity anomalies between the devices for future investigation and resolution.

USA	VISIBLE	USSR	VISIBLE
RAH66	No	T72M	No
AH64	No	T80	Yes
AH64D	No	BMP1	No
RAH66 LONGBOW	No		
CH47	No	BMP2	Yes
OH58D	Yes	BRDM2	Yes
VH60	Yes	BTR80	Yes
USUAV	No	BM21	No
A10	Yes	Z1L131_FDC	No
A10A AFSAF	Yes (A10)	1V13	No
F14D	No	1V14	No
F16C	No	1V15	No

F16D	No	1V16	No
ASTAMIDS	No	2B11	No
		2S12	No
M1	Yes	2S1	No
M1CPS(MINE ROLLEY)	Yes	2S19	Yes
M1A1	Yes	SAS	No
M1A2	Yes	SA15SAM	Yes
M60	No	ZSU-23-4	Yes
XM8	No	2S6	Yes
		XM3755	No
M2	No	XMG15	No
M3	No	SA6FCR	No
M3A3	No	SA6TEL	No
FOXYes		XMLTS	No
STINGRAY	No	XMTSS	No
M2_STINGER	No		
M113 AMBULANCE	Yes (A3)	MI8	No
M113 ENGINEER	No	MI24	No
M113 OBSERVER	No	MI28	Yes
M998 HMMWV	Yes	KA50	No
US DIFOFAC	Yes	USSRUAV	No
IMFWAM	No	MIG27	No
LOSAT	No	MIG27D	No
		MIG29	
M109	No	No	
M109A1	No	SU25	No
M109A3	No		
M109A5	Yes		
M109A6	Yes		
M198	No		
M270	Yes		
M35A2_FDC	No		
M577A1_FDC	No		
CRUSADER m977	No		

Table 16 Visibility of ModSAF Entities on CCTT

Refer to Appendices B, C and E of this document for specific observations recorded during the QS Module interoperability tests as well as analysis' and corrective actions.

5.0 TECHNICAL INNOVATION

The CDF Upgrade DO has sought innovative ways to increase CDF efficiency, prepare the CDFs for new simulators and support experiments. Trade studies were performed as necessary to select solutions that supported current requirements yet were flexible and expandable. Development was performed carefully, using our experience as a guide to manage DO risks. The following discusses technical innovations imbedded in CDF Upgrade tasks.

5.1 Network Upgrades

The Network Upgrade design provides an open framework for expansion to new networking technologies. A fiber backbone (2 cables with 24 fibers each) was installed at each site which can support Ethernet (10 or 100Mbs) over fiber, FDDI, and ATM as well as other high speed networking technologies. LAN switches were installed that are configured to support today's 10Mbs and FDDI requirements but can be expanded to support ATM and FastEthernet interfaces. The LAN switches also support Virtual LANs which reduce the amount of physical re-wiring necessary for unclassified experiments and support multiple experiments on the same network without significantly degrading performance. Network zones were developed to allow direct connection of workstations and simulators to the LAN switches to provide optimum network performance and ease of configuration.

The flexibility and effectiveness of the CDF DO planning and network design was demonstrated by the timely completion of the fiber network connections at the MWTB and LWTB sites. At MWTB, the CDF network was easily connected to the Ft. Knox SIMNET facility and TBBVB (TRADOC Brigade and Below Virtual BattleField). The connection to the TBBVB provides DSI connectivity for the Brigade C2V/BCV simulators to any DSI participants, which is a unique asset within the DIS community. The connection with the T-site provides access to the new CCTT and existing SIMNET simulators, bringing MWTB fully into the virtual and constructive simulation efforts at Ft. Knox. Similar capabilities are also now available at the LWTB LDTOC, which is connected to the LWTB network.

5.2 MWTB Interoperability

As part of the CDF Upgrade DO MWTB Interoperability Test, the CDF Upgrade DO demonstrated how to configure a shared Admin/DSI network connection to STRICOM and make use of the DSI node at STRICOM.

5.3 ModSAF Platforms

The investment in evaluating the most cost effective ModSAF platform architecture is making an impact on current experiments. The new architecture uses relatively high performance, yet low cost PC-based workstations for applications requiring an operator. Higher cost workstations with the maximum performance are included where the number of entities per workstation needs to be maximized. This is making it possible to run more complex scenarios with fewer, less expensive workstations. This new approach is already helping both AVTB and MWTB DOs that require large numbers of ModSAF entities for simultaneous experiments..

5.4 SINCGARS Rehost

The SINCGARS rehost effort pursued a PC-based solution but found that SGI's low-cost solution was in fact the most cost effective platform because of the audio processing requirements. As part of this effort, the DO investigated the CVSD encoding algorithms used by ADST I SINCGARS and CCTT SINCGARS and pursued a common solution which led to the interoperability of SINCGARS radios in the CCTT, SRE/SRM, and ASTi simulators.

5.4 CCTT Modules

The installation and operation of CCTT QS modules with DIS assets represented the first application of the new CCTT simulators in a non-homogeneous environment. With assistance from the CCTT Program, procedures and configurations were developed that allowed interoperation of the assets. Selection of a database that was available for all the simulators required careful research and led to a better understanding of interoperability issues.

5.5 Database Modeling

The ADST II database modeling capability was significantly enhanced by the CDF Upgrade DO with the procurement of a MultiGen Database Generation System. The MultiGen purchase was based on evaluating the ADST II needs for database modeling and conversion. The MultiGen system is based on the Open Flight database format and provides interfaces to S-1000, SIF, and CTDB formats. This asset is supporting further database interoperability research, as well as other DOs such as AC-130U. The database modeling facility is a foundation for further database modeling efforts.

5.6 ModX DIS 2.03/2.04 PDU Translator

The DIS 2.0.3 to 2.0.4 (Mod X) translator effort leveraged ADST II ModSAF expertise in devising a novel design approach to make DIS 2.03 devices interoperable with DIS 2.04 device by utilizing ModSAF libraries. The result was a stable translation tool that performed well in all tests. The CDF Upgrade DO is proposing that ModX be accepted into the ModSAF baseline and become part of the standard ModSAF release. For maximum efficiency, DIS translator efforts were coordinated with Combat ID and STOW EX DOs.

5.7 RWA Upgrades

~~The CDF Upgrade DO provided further upgrades to the AVTB RWA devices by procuring a 6-channel PC based image generation system to provide out the window and sensor imagery. This innovative design integrates stand alone PC stealths into a correlated 6 channel visual image generator and sensor display. This system represents a breakthrough price for medium performance visual systems, which enables an upgrade path for the replacement of legacy GT 111 IGs at other facilities. The replacement of the GT 111s grew out of the prototype implementation of newly developed PC stealths added to the CDF Upgrade DO (see paragraph 3.2.8). All CDFs now have MetaVR VRSG stealth systems and are experiencing extensive utilization on all TestBed DOs.~~

~~The Host computer systems have also been upgraded to stand alone PCs. This represents a leap forward in simulation technology and enables a upgrade path for other legacy SIMNET devices.~~

~~The replacement of the existing out the window display system is another innovative way of providing an inexpensive upgrade path for the future. The resolution of the out the window display was increased from NTSC video to XGA (1024x768). The design allows for the replacement of only the LCD projector without replacing the entire display when better projection equipment becomes available.~~

The CDF Upgrade DO provided further upgrades to the AVTB RWA devices by procuring a 6-channel PC-based image generation system to provide out-the-window and sensor imagery. This innovative design integrates stand-alone PC stealths into a correlated 6-channel visual image generator and sensor display. This system represents a breakthrough price for medium performance visual systems, which enables an upgrade path for the replacement of legacy GT-111 IGs at other facilities. The replacement of the GT-111s grew out of the prototype implementation of newly developed PC-stealths added to the CDF Upgrade DO (see paragraph 3.2.8). All CDFs now have MetaVR VRSG stealth systems and are experiencing extensive utilization on all TestBed DOs.

The Host computer systems have also been upgraded to stand alone PCs. This represents a leap forward in simulation technology and enables a upgrade path for other legacy SIMNET devices.

The replacement of the existing out-the-window display system is another innovative way of providing an inexpensive upgrade path for the future. The resolution of the out-the-window display was increased from NTSC video to XGA (1024x768). The design allows for the replacement of only the LCD projector without replacing the entire display when better projection equipment becomes available.

5.8 RWA Communication Switch Panels

A new simulated communications switch panel was developed for the RWAs to improve communication system fidelity. This switch panel combines functions from multiple switch panels found in operational helicopters and allows the crews to control their radios similar to the way they operate in the actual aircraft (selection of multiple channels for monitoring, selection of a single transmit channel, an intercom and a "hot mike". The switch panel was integrated into the ASTi radio servers and the SINCGARS SRMs to provide flexible configuration options, which may now include ASTi radios without terrain affects and SINCGARS radios that compute terrain affects.

5.9 Removable Disk Drives

A removable disk drive trade study was performed to select a supplier for external removable disk drives for standardization across CDFs. These units are generally applicable to all workstations that have SCSI II interfaces. Removable disks increase operational efficiency by allowing a quick re-configuration from classified to unclassified without having to spend the time to declassify the disk drives. This notion was expanded to the PC-based ModSAF workstations, which were procured with removable drives. External tapes and CD-ROMs were also procured that improve operations for similar reasons.

5.10 Operating System Updates

Where possible, the latest version of operating system was procured for the new workstations. To benefit from rapid changes in commercial systems, CDF platforms must be kept up to date to remain compatible. Software maintenance contracts keep software up to date and avoid added cost to DOs when they need to run new software requiring the latest version of the operating systems. Upgrading operating systems must continue to not become an impediment to innovation at the CDFs.

6.0 CONCLUSION

The CDF Upgrade DO accomplished its mission to prepare the CDFs for new simulators and improve our capabilities to support future experiments. Based on the experience gained from this DO additional upgrade requirements have been identified that are necessary to provide a robust and viable environment for future synthetic environment experiments. This section summarizes the accomplishments of the CDF Upgrade DO and provides lessons learned for future DOs. The section then concludes with a roadmap for future CDF Upgrade efforts.

Accomplishments

The CDF DIS Confederation facilities are now better able to support DoD or commercial customers to conduct DIS experiments and exercises. CDF sites including the MWTB at Fort Knox, AVTB at Fort Rucker, the LWTB at Fort Benning; and the OSF at Orlando, all received significant new

capabilities and equipment.

The CDF Upgrade DO provided the infrastructure for the next generation of CDF simulators (CCTT and BLRSI devices), and enhanced the capability to fully simulate weapons systems (including sensor models, weapons models, communication, battlefield representation). The objectives of the CDF Upgrade effort have been accomplished:

- The CDFs are ready for the implementation of new simulators such as Close Combat Tactical Trainer (CCTT) and Battle Lab Reconfigurable Simulator Initiative (BLRSI) which require FDDI (or other media over fiber) networks.
- Support for synthetic environment experiments has been enhanced through the addition of new and upgraded assets for CCTT manned simulators, RWAs, ModSAF, Datalogging, DISAT, Stealth, SINCGARS and ancillary equipment.
- CDF operational efficiency has been improved with the addition of external peripherals including disk drives and tapes and a new pool of spare parts.
- Continuous upgrades have been accomplished through the flexibility of the DO and IPT process. Products that became available during the execution of the DO have been implemented and are impacting DOs even before the CDF Upgrade DO was complete.

In addition, the CDF Upgrade DO supported other ADST II DO efforts through adapting to changing requirements and leveraging emerging technology. CDF Upgrade CLIN 4 results led to funding of additional tasks under CLIN 13. These tasks include RWA Upgrade, M1A2 Upgrade mini-FAS, ATM TestBed, DIS test suite development, image generation interoperability database, interoperability system enhancements, VV&A roadmap/analysis tools, and remote exercise preparation and control.

Lessons Learned

The accomplishments of this DO provided insight and understanding of many aspects of DIS experimentation and support. Future CDF upgrade DOs are considered to be important and necessary for the robust support of the simulation community, prototype system evaluation and training systems development. These future efforts should consider:

- The IPT process is vital to adjust directions, reprioritize tasks and evaluate results to keep the DO responsive to changing requirements and new technology.
- Purchases of relatively simple catalog items need to be followed and evaluated because commercial products are changing rapidly and may not be completely compatible.
- Other DOs made use of the CDF Upgrade DO to provide permanent assets that were not funded or were unexpected requirements and not planned. Having the CDF Upgrade DO as an additional source for resources lessened the burden on the experimental DOs and improved the CDFs responsiveness. A similar mechanism to the CDF Upgrade DO should be considered for future funding years.
- Interoperability between simulation assets hinges on a common, interoperable database. The ease of developing and executing an experiment with heterogeneous assets requires advanced planning on what database will be used, what assets it is available for, and how adjustments will be made.
- DSI use within an experiment continues to be a complex requirement, which demands careful planning and coordination. The DSI service provided predictable results but outages were experienced. DSI network management should be contacted prior to testing so they understand the requirements. The HAI staff was very responsive and able to recover quickly when they were called about a problem.

- The E&S CCTT database is not easy to change. Any new requirements need to be carefully evaluated. Changes may only be made by E&S and need a long lead-time.

- ~~Low-cost PC-based stealths emerged during this DO as viable alternatives in many situations to higher-priced workstations. ModSAF is hosted on a PC platform and the RWA/FWA Host is now on a PC platform. PC-based IGs were evaluated and found to be viable alternatives to dedicated image generators. This trend is expected to continue and needs to be followed in order to determine which solutions are cost-effective replacements for existing assets.~~ Low-cost PC-based stealths emerged during this DO as viable alternatives in many situations to higher-priced workstations. ModSAF is hosted on a PC platform and the RWA/FWA Host is now on a PC platform. PC-based IGs were evaluated and found to be viable alternatives to dedicated image generators. This trend is expected to continue and needs to be followed in order to determine which solutions are cost-effective replacements for existing assets.

CDF Upgrade Roadmap

Future experiments at the CDFs will have requirements that are beyond the scope of the CDF Upgrade DO efforts covered in this report. Some areas are being addressed with a follow-on CDF Upgrade DO but much still remains to be done. A roadmap for these initiatives is shown in Table 17. It encompasses a strategy to make use of existing assets while realizing that new simulators based on new processors and software will better meet interoperability and functional demands. The new requirements focus on the way the CDFs participate with other sites to perform experiments; on the interoperability of the simulators and on new simulator capabilities. Forming a base to support the future requirements, the CDF infrastructure (ancillary devices for ModSAF, datalogging, analysis, etc.) and operations will require continuous improvement.

	1997	1998	1999	2000-2002
Interfaces	**HLA Testbed** **HLA ModSAF**	CDF HLA Compliance **HLA Exercise Control**	HLA Reconfigurables, Upgrade M1A1s, RWA/FWAs HLA Exercise Control	Replace Balance of Sims HLA Compliant Reconfigurable, Adv. Env. Representation, DB Interop, RWA/FWA I/O VV&A, C4I
	ATM Testbed **LAN Upgrades**		WAN Upgrades High Speed Secure	
Interoperability	**Standard Test Database**	Environment Representation	Adv. Envir. Rep.	
		DB Interop with SEDRIS	DB Interoperability	DB Interop with SEDRIS
	CCTT Modules Integrated with DIS	Reconfigurable Sims ***M1A2 Upgrade*** ***RWA Upgrade***		
New Capabilities	**Image Generators**	***PC-Based IG***	**IG Upgrades**	
		PC Based Host Computer	PC Based Host Computer Upgrades	
	Voice Com	C4I, FBCB2	C4I, FBCB2	
	VV&A Roadmap		VV&A Models	
Operations	**Spares**	Spares	Spares	Spares
	Infrastructure	Infrastructure	Infrastructure	Infrastructure
NOTE: Bold items are in progress. Bold italics items are complete.				

Table 17 Upgrade Roadmap

Looking at the near-term (1998 and 1999), effort is needed to complete CDF HLA compliance, and fully implement the remote exercise control that spans DIS and HLA environments. As the HLA technology matures, changes to legacy simulators will be required to operate in HLA native mode and avoid the complexities of translators.

Interoperability of the simulation assets will continue to be a serious concern as devices from many different sources are linked and expected to accurately participate in a synthetic environment. The Standard Interoperability Database needs to be used to uncover problems and test proposed solutions such as SEDRIS. This effort will lead to improved database interoperability and towards the goal of arbitrary mixtures of heterogeneous simulators interoperating with terrain correlation. In addition, advanced environmental representations need to be added to the databases used to enhance experiment fidelity and expand the range of applications for synthetic environments.

The CDF Upgrade DO follow-on effort (CLIN 13) included dramatic upgrades to the M1A2s and the RWA/FWAs. PC-based systems continue to become more powerful for less cost. These should be pursued as viable upgrades to existing assets to increase the number of manned simulators available. In addition, new reconfigurable simulators are needed that offer advanced functionality with better image quality and maintainability similar to that of the upgraded RWA assets.

Voice and data communications have changed dramatically during the CDF Upgrade DO. This trend is expected to continue as command and control data continues to grow, situation awareness data improves and network connections in the battlefield further develop. Integration of C4I and FBCB2 into the CDF assets is needed to provide assets suitable for experiments with this new technology.

With the preparation of the CDFs for FDDI devices locally, they were prepared for higher bandwidth WAN connections. While the timing of when WAN upgrades will be needed isn't known, we should assume upgrades will be required. The investigations into ATM should be followed with investigations into other high speed networking technology such as gigabit Ethernet. Higher bandwidth connections with customer sites could open new experimental areas where the CDF assets could be applied.

Finally, in the near-term, a continuation of the infrasture upgrade and operation support is needed. The rapidly changing computational environment makes it imperative that the CDFs remain on the forefront of developments to support the new devices that customers will develop. Development isn't done on obsolete legacy equipment; it's done with the latest, most powerful and productive hardware and software. Experience with the CDF Upgrade DO demonstrated the value of having continuously improved resources available by being able to support rapidly changing and newly emerging requirements.

As we move forward into the later years, it will be necessary to institute a program to replace aging simulators with new devices that comply with the interface and database standards, use less expensive more powerful processors, and can be modified to meet the needs of future DOs.

7.0 CDRL ITEM LIST

Table 18 lists the CDRL items delivered under the CDF Upgrade DO:

Document Number	Title	Date	CDRL No.	Applicable DID
ADST-II-CDRL-003R-96000245-B	Test Plan for the CDF SINCGARS Radio Model at MWTB	4/30/97	AB01	DI-MISC-80711
ADST-II-CDRL-003R-9600290-A	Interoperability Tests for the QS Modules at OSF	7/25/97	AB01	DI-MISC-80711
ADST-II-CDRL-003R-9600302-B	Interoperability Tests for the QS Modules at LWTB	8/1/97	AB01	DI-MISC-80711
ADST-II-CDRL-003R-9600305-B	Test Plan for the CDF SINCGARS Radio Emulator at AVTB	8/15/97	AB01	DI-MISC-80711
ADST-II-CDRL-003R-9700124-A	Long Haul Interoperability Test Plan Between OSF and MWTB	6/15/97	AB01	DI-MISC-80711
ADST-II-CDRL-003R-9700241	CDF Upgrade Final Report	9/30/97	AB02	DI-MISC-80711
ADST-II-CDRL-003R-9600468-B	Version Description Document for the SINCGARS Simulator 4.1	6/6/97	A00C	DI-MCCR-80013A
ADST-II-CDRL-003R-9600485-A	Version Description Document for the SUN5 DCA Tool Set (Rehosted DISAT/Datalogger)	2/14/97	A00C	DI-MCCR-80013A
ADST-II-CDRL-CDF-9700092-A	Version Description Document for the SUN5 DIS Translator (MOD-X)	4/4/97	A00C	DI-MCCR-80013A

Table 18 CDRL Item List

8.0 ACRONYMS

Acronym/Abbreviation	Definition
A2ATD	Antiarmor Advanced Technology Demonstration
AAR	After Action Review
AC	Alternating Current
AG	Application Gateway
AGL	Above Ground Level
AVTB	Aviation Testbed
AVTOC	Aviation Tactical Operations Center
AWC	Advanced Warfighter Cell
BIT	Built-In-Test
BLRSI	Battle Lab Reconfigurable Simulator Initiative
C4B	Compact Terrain Database, Version 4
C5B	Compact Terrain Database, Version 5
C7B	Compact Terrain Database, Version 7
CCTT	Close Combat Tactical Trainer
CCW	Counter-Clockwise
CDF	Core DIS Facility
CDRL	Contract Delivery Requirement List
CHAN	Channel
CLIN	Contract Line Item Number
COMSEC	Communications Security
COTS	Commercial Off the Shelf
CPH	Commander's Popped Hatch
CTDB	Compact Terrain Database
CW	Clockwise
DCA	Data Collection Analysis
DIS	Distributed Interactive Simulation
DISAT	Distributed Interactive Simulation Analysis Tool
DO	Delivery Order
DRC	Daily Readiness Check
DSI	Defense Simulation Internet
ERF	Electronic Remote Fill
FAT	First Article Test
FBCB2	Force XXI Battle Command - Brigade and Below
FCTN	Function
FDDI	Fiber Distributed Data Interface
FRACAS	Failure Reporting, Analysis and Corrective Action System
GDF	General Database Format

Acronym/Abbreviation	Definition
GFE	Government Furnished Equipment
GPS	Gunner's Primary Sight
GUI	Graphic User Interface
HAI	Houston Associates Inc.
IG	Image Generator
INT	Internal
IP	Integrated Product
IPT	Integrated Product Team
ISU	Integrated Sight Unit
IVC	Instructor Voice Channel
JCSAR	Joint Combat Search and Rescue
Km	Kilometer
LDTOC	Light Digital Tactical Operations Center
LMIS	Lockheed Martin Information System
LOSAT	Line-of-sight Anti-Tank
LRF	Laser Range Finder
LWTB	Land Warrior Testbed
MaK	Dial-a-tank desktop Simulator & Stealth Developer
MC	Maintenance Console
MCC	Master Control Console
MGRS	Military Grid Reference System
MOD-X	ModSAF Translator
MWTB	Mounted Warfare Testbed
N/A	Not Applicable
NGUV	Next Generation Unmanned Vehicle
NLOS	Non Line-of-sight
NTC	National Training Center
NVG	Night Vision Generator
OPFOR	Opposing Forces
OS	Operating System
OSF	Operational Support Facility
OTW	Out The Window
PA	Power Amplifier
PDU	Protocol Data Unit
PIE	Programmaable Interface Electronics
PLGRS	Precision Lightweight GPS Recievers
POST	Power On Self Test
PPR	Program Problem Report
PT	Plain Talk
PTT	Push to Talk
PUI	Project Unique Identifier
PVD	Plan View Display

Acronym/Abbreviation	Definition
QS	Quick Start
REM	Remote
RPN	Research Park Network ,at STRICOM, Orlando FL
RT	Receiver-Transmitter
RWA	Rotary Wing Aircraft
SAS	Single Attachment Station
SC	Single Channel
SD	Standalone Double
SIMNET	Simulation Network
SINCGARS	Single Channel Ground and Airborne Radio System
SME	Subject Matter Expert
SOW	Statement of Work
SQ ON	Squelch On
SRE	SINCGARS Radio Emulator
SRM	SINCGARS Radio Model
STRICOM	Simulation, Training and Instrumentation Command
TBBVB	TRADOC Brigade and Below Virtual Battle Field
TBD	To Be Determined
TOC	Tactical Operations Center
TRR	Test Readiness Review
TSSE	Trainer Software Support Environment
VDD	Version Description Document
VLAN	Virtual LAN
VRSG	Virtual Reality Scene Generators
WAN	Wide Area Network
XCAU	Experimental Cell Adapter Unit
XCIAU	Experimental Cell Interface Adapter Unit

ADVANCED DISTRIBUTED SIMULATION TECHNOLOGY II (ADST II)

CDF UPGRADE DELIVERY ORDER 0013

APPENDIX A

TEST REPORT FOR THE CDF SINCGARS RADIO MODEL AT MWTB

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BY: **Lockheed Martin Corporation**
ADST II
PO Box 780217

N61339-96-D-0002
DI-MISC-80711

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1. SCOPE

1.1 Purpose

This report describes the results of an interoperability test conducted on upgraded Single Channel Ground and Airborne Radio System (SINCGARS) simulators, also called SINCGARS Radio Models (SRM). The tests were organized into Groups consisting of one stand-alone and three interoperability series. The tests were conducted April 9 thru 11, 1997, in a controlled environment, at the Mounted Warfare Testbed (MWTB), Ft. Knox, Kentucky. Personnel from the Operational Support Facility (OSF), Orlando, Florida, coordinated and managed the tests with support from MWTB technical staff. A total of fourteen (14) upgraded SRMs were fielded at the MWTB under the Core Distributed Interactive Simulation (DIS) Facilities (CDF) Upgrade Delivery Order (DO) 0013.

This test report is prepared in accordance with Data Item Description (DID) DI-MISC-*80711*. The test procedures are contained in Appendix A of Test Plan ADST-II-CDRL-003R-9600245-B.

1.2 System Description

The SRM Simulator models the radio equipment by means of a Graphic User Interface (GUI) which displays two radios, the bottom position called Radio A, and the top position called Radio B. Each radio features a Control/Display Panel with LED alphanumeric display and keyboard, a Radio Frequency (RF) switch, Function (FCTN) switch, Channel (CHAN) switch, Communications Security (COMSEC) switch, Dim (DIM) switch, Volume/Whisper (VOL/WHSP) control, and Mode switch. Additional SRM hardware consists of the host platform, keyboard, mouse, microphone and speaker.

The SRMs can operate on either DIS 2.03 or 2.04 Protocol which enables them to communicate with DIS M1A2 and Close Combat Tactical Trainer (CCTT) simulators at the MWTB. Since no CCTT Modules were available for the tests, all devices operated on DIS 2.03 protocol.

1.3 Technical Overview

The CDF SRM was upgraded with a new version of the SINCGARS software (v. 4.0). The new software was developed to provide interoperability between existing configurations of stand-alone or vehicle-mounted SINCGARS, and the CCTT SINCGARS. The new software also provided the CCTT Instructor Voice Channel (IVC) capability to the older SINCGARS configurations. The IVC provides the Instructor/Operator (I/O) with the ability to interrupt/override normal tactical communication, and establish open-channel contact to and

from any/all simulators connected to the IVC. The terrain propagation model, and maximum range limitations, are also overridden in the IVC mode. If the IVC connection is terminated, the radios automatically return to normal (tactical) mode. The tests included two CDF SRMs, one Anti-Armor Advanced Technology Demo (A2ATD) SINCGARS Radio Emulator (SRE) and the DIS M1A2 SINCGARS. All radios were operating with the SINCGARS v.4.0 software. A Modular Semi-Automated Forces (ModSAF) station was used to establish the terrain board, and provide vehicle entities to which the stand-alone radios were attached or tethered.

2. REFERENCED DOCUMENTS

2.1 Government Documents

2.1.1 Data Item Description

DI-MISC-80711	Scientific and Technical Reports - Organization, Preparation and Production

2.1.2 Test Plan

ADST-II-CDRL-003R-9600245-B	Test Plan for the SINCGARS Radio Model at MWTB

3. TEST ENVIRONMENT

3.1 Test Components

3.1.1 Hardware Items/Simulators

See Figure 1 for the interconnectivity between Hardware Items/Simulators, and Table I for a listing of Hardware Items/Simulators included within the test environment.

3.1.2 Software Items

See Table I for a listing of the software items included within the test envrionment.

3.1.3 Databases

See Table I for a listing of the databases included within the test envrionment.

3.1.4 Radio Operating Data

1. Single Channel (SC) Mode: None (operating frequencies were manually loaded).
2. Frequency Hopping (FH) Mode: FH Hopsets were loaded from Net Control Station (NCS) via Electronic Remote Fill (ERF) or Cold Start Net Opening.

MWTB Network Hub Test Configuration

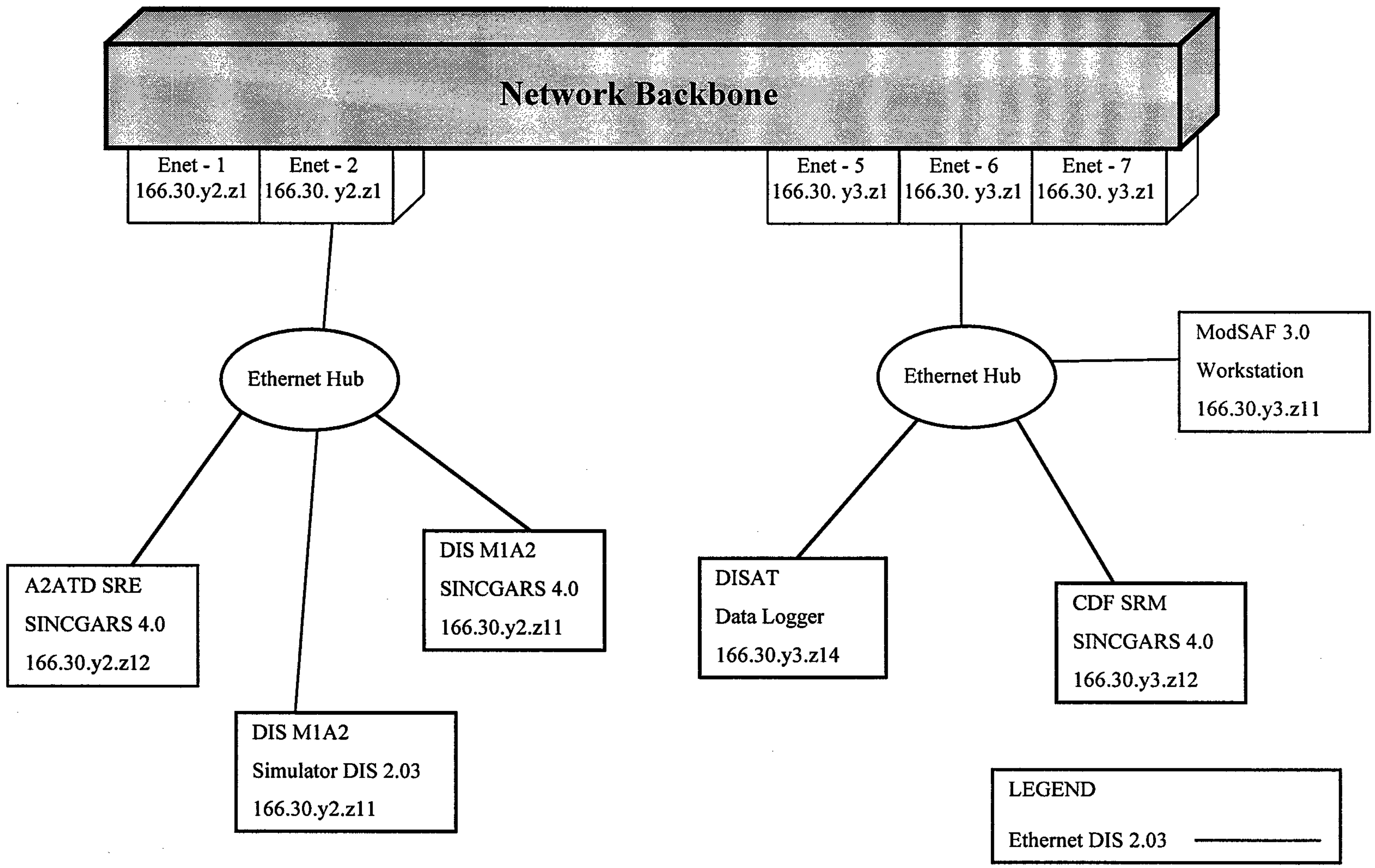

Figure 1. MWTB Network Hub Test Configuration

	APPLICATIONS	QTY	H/W	DB	DIS	OS	NETWORK
1	A2ATD SINCGARS 4.0	1	SGI Indy R4600/133 MHz CPU w/ 96 Mb RAM	NTC C4B	2.03	IRIX 5.2/6.2	Ethernet
2	CDF SINCGARS 4.0 (TOC1 and NCS)	2	SGI Indy R4600/133 MHz CPU w/ 96 Mb RAM	NTC C4B	2.03	IRIX 5.2/6.2	Ethernet
3	DIS M1A2	1	VMEbus/ONYX	Vistaworks 6.1.0B	2.03	IRIX 5.2	Ethernet
4	M1A2 SINCGARS 4.0	1	SGI Indy R4600/133 MHz CPU w/ 96 Mb RAM	NTC C4B	2.03	IRIX 5.2/6.2	Ethernet
5	ModSAF 3.0	1	SGI Indy R4400/100 MHz CPU w/ 64 Mb RAM	NTC C7B	2.03	IRIX 5.2	Ethernet

Table I. MWTB Test Components

3.2 Security

3.2.1 Classified Material

No classified or sensitive data, equipment, or other material was used to conduct or support the tests.

3.2.2 Access To Test Suite

Access to the test suite/environment was restricted to the equipment operators, Subject Matter Experts (SME) and Data Recorders/Monitors assigned to support the test.

3.2.3 Test Environment

All items within the Test Environment to include hardware, software and database elements under test were controlled by the on-site Test Director.

3.3 Test Organization

3.3.1 Test Organization by Groups

Each Test Group consisted of a series of tests which evaluated a specific area of system functionality. Test Plan ADST-II-CDRL-003R-9600245-B contains four (4) primary Test Groups as follows:

1. Stand-alone Tests (Group I)
2. Two-Way Communication Tests-Single Channel (SC) Operating Mode (Group II)
3. Two-Way Communication Tests-Frequency Hopping (FH) Operating Mode (Group III)
4. Instructor Mode/IVC and Clearing FH Data Tests (Group IV)

3.3.2 Test Organization by Parts

Test Groups were subdivided into Parts which identified each unique test within that Group

3.3.3 Project Unique Identifiers (PUI)

Test Groups were identified by Roman Numerals in consecutive sequence and Parts were identified by numeric designators in consecutive sequence. The PUI II-1 designated the first Part of the second Test Group.

3.4 Test Methodology

3.4.1 Test Station

A Tactical Operation Center (TOC) was established as the Test Station, which included the associated entity (i.e. call sign and bumper number) required for each stand-alone SINCGARS configuration under test.

3.4.2 Test Sequence

1. Group I: All 14 CDF SRMs completed Group I Tests before commencing Test Groups II thru IV.
2. Groups II, III, and IV: One SRM was designated as the First Article Test (FAT) unit and underwent the tests of Group II, III, and IV.

4. TEST IDENTIFICATION

4.1 Stand-Alone Tests (Group I)

This series of Tests evaluated the performance of specific functions of the SRMs that did not involve interplay with other simulators/equipment. This Test Group consisted of four (4) Parts, and was conducted on all CDF SRMs, to include Radios A and B of each unit. Refer to Section 4 of Test Plan ADST-II-CDRL-003R-9600245-B for a detailed description of each Part.

4.2 Interoperability Tests-Single Channel Mode (Group II)

This series of tests evaluated the operational interface of one CDF SRM with an A2ATD SRE, and a DIS M1A2 SINCGARS Radio, with all radios operating in the Single Channel Mode. Group II consisted of four (4) Parts. Refer to Section 4 of Test Plan ADST-II-CDRL-003R-9600245-B for a detailed description of each Part.

4.3 Interoperability Tests-Frequency Hopping Mode (Group III)

This series of tests addressed the same equipment interoperability as Group II, except that all radios were operating in the Frequency Hopping Mode. The same radios/devices from Group II Testing were used for Group III Testing, with the addition of one more CDF SRM, which served as the Net Control Station (NCS) required to perform an Electronic Remote Fill (ERF). This group consisted of three (3) Parts. Refer to Section 4 of Test Plan ADST-II-CDRL-003R-9600245-B for a detailed description of each Part.

4.4 Instructor Mode/IVC Tests and Clearing FH Data (Group IV)

This series of tests evaluated the special communication features which are available when the Instructor Mode or Instructor Voice Channel (IVC) is enabled. This series also verified the capability to clear FH data from the SRM. Group IV consisted of two (2) Parts. Refer to Section 4 of Test Plan ADST-II-CDRL-003R-9600245-B for a detailed description of each Part.

5. TEST RESULTS

5.1 Observations

The Tests were conducted successfully with no reported failures. Two (2) problems were encountered during conduct of the test which were both attributed to operator or procedural error. The first problem involved incorrect activation and operation of the DIS M1A2 Commander's remote intercom system. The second problem involved procedural errors in setting up and executing the ERF from the NCS. Both problems were corrected and the equipment functioned properly. Appropriate red-line corrections/updates were incorporated into Test Plan ADST-II-CDRL-003R-9600245-B.

5.2 Conclusions

The MWTB SRM tests demonstrated that SINCGARS radios of different configurations can interoperate satisfactorily when running the CDF version 4.0 software. The tests also demonstrated that when IVC is enabled, the I/O station can connect to the different SINCGARS configurations, and will then override tactical communication, switch settings, operating modes, range limitations and terrain propagation models until disconnected.

5.3 Recommendations

Suggest conducting additional controlled tests involving multiple SINCGARS (6 or more), in conjunction with manned simulators and ModSAF entities, with the objective of gradually stressing the network/environment. The purpose is to isolate/identify the cause of "abnormal terminations/crashes" exhibited by the SINCGARS (all configurations) during recent CDF exercises/experiments.

6. NOTES

6.1 Acronyms and Abbreviations

Acronym/Abbreviation	Definition
A2ATD	Anti-Armor Advanced Technology Demonstration
BATT	Battery
C4B	Compact Terrain Database Version 4
C7B	Compact Terrain Database Version 7
CCTT	Close Combat Tactical Trainer
CCW	Counter Clockwise
CDF	Core DIS Facility
CHAN	Channel
CHG	Change
CLR	Clear
CMSC	COMSEC
COMSEC	Communications Security
CT	Cipher Text
CTDB	Compact Terrain Database
CW	Clockwise
DIM	Dimmer
DIS	Distributed Interactive Simulation
DO	Delivery Order
ERF	Electronic Remote Fill
FAT	First Article Test
FCTN	Function
FDDI	Fiber Distributed Data Interface
FH	Frequency Hopping
FREQ	Frequency
GUI	Graphical User Interface
HI	High
INT	Internal
IVC	Intructor Voice Channel
km	kilometer
LD	Load
LED	Light Emitting Diode
LO	Low
LOUT	Lockout
M	Medium
MAN	Manual

Acronym/Abbreviation	**Definition**
MWTB	Mounted Warfare Testbed
N/A	Not Applicable
NCS	Net Control Station
OFST	Offset
OSF	Operational Support Facility
PA	Power Amplifier
PT	Plain Talk
PUI	Project Unique Identifier
QS	Quick Start
REM	Remote
RF	Radio Frequency
RT	Receiver Transmitter
RV	Radio Variable
RXMT	Retransmit
SC	Single Channel
SGI	Silicon Graphics Incorporated
SINCGARS	Single Channel Ground-To-Air Radio System
SME	Subject Matter Expert
SQ OFF	Squelch Off
SQ ON	Squelch On
SRE	SINCGARS Radio Emulator
SRM	SINCGARS Radio Model
STBY	Standby
STO	Store
STRICOM	Simulation, Training and Instrumentation Command
SYNC	Synchronize
TBD	To Be Determined
TD	Time Delay
TOC	Tactical Operations Center
TST	Test
VOL/WHSP	Volume/Whisper
WINTERM	Window Terminal
Z	Zero
Z-FH	Zero-Frequency Hopping

ADST-II-CDRL-CDF-9700241
September 26,1997

ADVANCED DISTRIBUTED SIMULATION TECHNOLOGY II (ADST II)

CDF UPGRADE DELIVERY ORDER 0013

APPENDIX B

TEST REPORT FOR THE LONG HAUL INTEROPERABILITY TEST BETWEEN OSF AND MWTB

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BY: Lockheed Martin Corporation
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N61339-96-D-0002
DI-MISC-80711

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1. SCOPE

1.1 Purpose

This report describes the results of a long haul interoperability test between an M1A1 Close Combat Tactical Trainer (CCTT) Quick Start (QS) Module, Commander's Popped Hatch (CPH) configuration and a Distributed Interactive Simulation (DIS) M1A2 Simulator. The tests were organized into groups which addressed visual, communication and limited tactical operability between devices. The tests were conducted between the Mounted Warfare Testbed (MWTB), Ft. Knox, Kentucky and the Operational Support Facility (OSF), Orlando, Florida. The test included one M1A1 QS Module located at the OSF and one DIS M1A2 Simulator located at the MWTB. The Simulation, Training and Instrumentation Command (STRICOM) Defense Simulation Internet (DSI) provided interconnectivity between the two sites. This task was part of the interoperability test series under the Core Distributed Interactive Simulation (DIS) Facilities (CDF) Upgrade Delivery Order (DO) 0013

This test report is prepared in accordance with Data Item Description (DID) DI-MISC-80711. The test procedures are contained in Appendix A of Test Plan ADST-II-CDRL-9700124-A.

1.2 System Description

The M1A1 CCTT QS Module provides high-fidelity, full-crew interactive training by replicating the internal crew positions (Commander, Gunner, Loader and Driver compartments) of the M1A1 Abrams Main Battle Tank. Functional subsystems include the Fire Control System,Weapons/Ammo System, Power System (electrical and hydraulic), Sound Generation System and Visual Display/Image Generator. The CPH feature allows the Commander to view the surrounding terrain from "outside" the vehicle through a bank of visual displays/screens on top of the trainer that provides a 360 degree field of view.

The MWTB M1A2 is a former Simulation Network (SIMNET) device which has been upgraded to DIS. It also replicates the four crew positions to a lesser degree of fidelity than the CCTT QS Module. During operation, the Commander, Gunner and Driver positions are interactive. The Loader's position functions in automatic mode. All four crew positions have radio headsets that allow full-crew communication.

1.3 Technical Overview

The CCTT QS Module at the OSF operates on the DIS 2.04r protocol while the DIS M1A2 simulator at MWTB operates on DIS 2.03. The Modular Semi-Automated Forces (ModSAF) workstations and the Single Channel Ground and Airborne Radio System (SINCGARS) can operate on either DIS protocol. An Experimental Cell Adapter Unit (XCAU), also called the ModSAF Translator (Mod X), was developed under the CDF Upgrade DO, to translate standard DIS 2.03 Protocol Data Units (PDU) to DIS 2.04, and vice versa. The translations allow the QS Module and the MWTB M1A2 to interoperate. In addition, the Mod X provided interoperability between the MWTB ModSAF station and SINCGARS (DIS 2.03) and the OSF ModSAF and SINCGARS (DIS 2.04). The key objective of the tests was to evaluate device interoperability, between the DSI-connected CDFs, thru the Mod X.

2.0 REFERENCED DOCUMENTS

2.1 Government Documents

2.1.1 Data Item Description

DI-MISC-80711	Scientific and Technical Reports - Organization, Preparation and Production

2..1.2 Test Plan

ADST-II-CDRL-CDF-9700124-A	Long Haul Interoperability Test Plan Between OSF and MWTB

3. TEST ENVIRONMENT

3.1 Test Components

3.1.1 Hardware Items/Simulators

See Figure 1 for the interconnectivity between Hardware Items/Simulators, and Table I for a listing of Hardware Items/Simulators included within the test environment.

3.1.2 Software Items

See Table I for a listing of the software items included within the test environment.

3.1.3 Databases

See Table I for a listing of the databases included within the test environment.

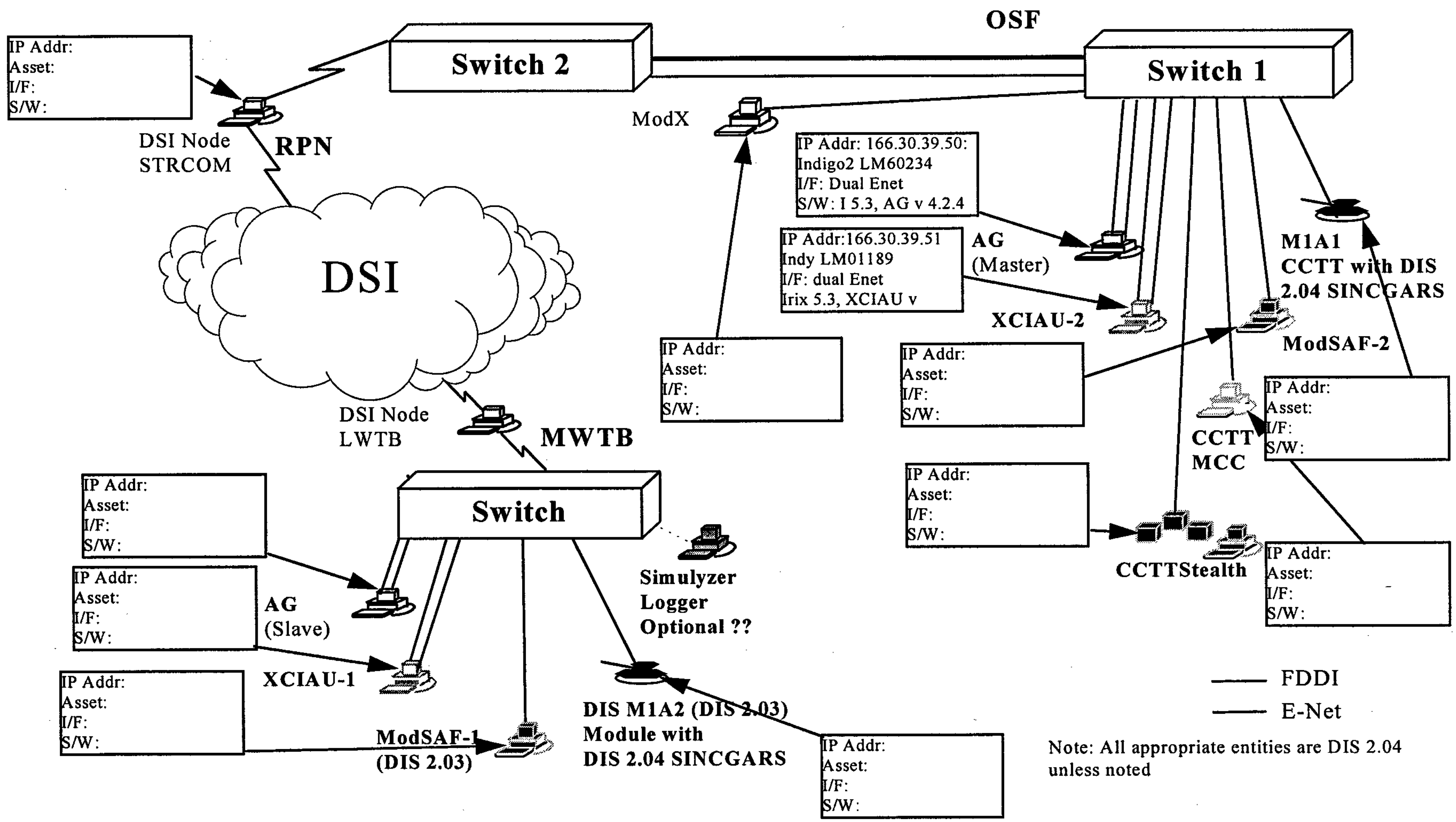

Figure 1. Long Haul Network Hub Test Configuration

	APPLICATIONS	QTY	H/W	DB	DIS	OS	NETWORK
1.	CCTT Stealth	1	RISC 6000/ESIG 3000	NTC GDF	2.04r	AIX 4.14	FDDI
2.	ModSAF 3.0	1	SGI Indy R4400/100 MHz CPU w/ 96 Mb RAM	NTC C4B	2.03	IRIX 5.3	Ethernet
3.	DIS M1A2	1	SGI ONYX IG	Vistaworks NTC S1000	2.03	IRIX 5.2	10B5 Ethernet AUI Conn.
4.	M1A1 CCTT QS Module	1	RISC 6000/ESIG 3000	GDF NTC ctdb	2.04r	AIX 4.14	FDDI Single Attached
5.	MCC	1	RISC 6000	n/a	2.04r	AIX 4.14	FDDI
6.	XCIAU	1	SGI Indy R4400/100 MHz CPU w/ 96 Mb RAM	n/a	2.03 2.04	IRIX 5.3	FDDI SAS/Ethernet
7.	Mod X	1	SUN SPARC Ultra/166 MHz CPU w/ 128 Mb RAM	n/a	2.03 2.04	SUN 5.5.1/ Solaris 2.5	FDDI SAS/Ethernet

Table I. Long Haul Test Components

3.2 Security

3.2.1 Classified Material

No classified or sensitive data, equipment, or other material was used to conduct or support the tests.

3.2.2 Access To Test Suite

Access to the test suite/environment was restricted to the equipment operators, Quality Assurance, SME/Observers and Data Recorders/Monitors assigned to support the test.

3.2.3 Test Environment

All items within the test environment to include hardware, software and database elements under test were controlled by the on-site Test Director/Manager.

3.3 Test Organization

3.3.1 Test Organization by Groups

Test groups consisted of a series of tests which evaluated a specific area of system functionality. Test Plan ADST-II-CDRL-CDF-9700124-A contains three primary test groups as follows:

1. Communication/Interconnectivity Tests (Group I)
2. Visual/Line Of Sight (LOS)/Non Line Of Sight (NLOS) Tests (Group II)
3. Limited Tactical Operability Tests (Group III)

3.3.2 Test Organization by Parts

Test groups were subdivided into parts which identified each unique test within that group.

Project Unique Identifiers (PUI)

Test groups were identified by Roman numerals in consecutive sequence and parts were identified by numeric designators in consecutive sequence. The PUI II-1 designated the first part of the second test group.

3.4 Test Methodology

3.4.1 Test Station

Separate test stations were established at each site to coordinate/execute all dry run and formal test activities under the direction of the on-site test managers.

3.4.2 Test Sequence

The M1A1 QS Module and the DIS M1A2 Simulator underwent groups I, II and III tests. The test groups were conducted in consecutive order and all parts of a group were completed before beginning the next group.

4. TEST IDENTIFICATION

4.1 Communication/Interconnectivity Tests (Group I)

This series of tests established and verified interconnectivity between sites, via the DSI, and then evaluated two-way communication between the QS Module and the DIS M1A2. In the two-way communication test, the on-board SINCGARS Radios and vehicle intercom boxes at each crew position were used to transmit and receive between the vehicles. Refer to Section 4 of Test Plan ADST-II-CDRL-CDF-9700124-A for a detailed description of each Part.

4.2 Visual/LOS/NLOS Tests (Group II)

This series of tests evaluated interoperability between the M1A1 QS Module, DIS M1A2, Stealth and ModSAF visual displays. The objective of these tests was to evaluate/compare/ correlate the different entity (vehicle/aircraft) appearances and states on each of the visual displays. Refer to Section 4 of Test Plan ADST-II-CDRL-CDF-9700124-A for a detailed description of each Part.

4.3 Limited Tactical Operability Tests (Group III)

This series of tests verified that the M1A1 QS Module and the DIS M1A2 can detect, engage and break contact with ModSAF enemy/OPFOR ground and air entities. Refer to Section 4 of Test Plan ADST-II-CDRL-CDF-9700124-A for a detailed description of each Part.

5. TEST RESULTS

5.1 Observations

1. OSF entities flickered (disappeared/reappeared) on MWTB ModSAF which resulted in degradation, followed by complete loss, of communication from the OSF to MWTB.

Analysis: This anomoly occurred during execution of the ModSAF RWA attack mission (MI-28 flight of 5) at which time the network sniffer indicated a significant increase in PDU traffic across the DSI. The result was an intermittant over-load of the WAN which caused interruption of PDU transmisions. This in turn caused entities to temporarily disappear/reappear, which disrupts radio communication, as the SINCGARS are tethered to the entities. After the RWA attack mission terminated, the anomoly was no longer observed.

Corrective Action: Recommend investigation into the the number, type and frequency of PDU transmissions that occur during execution of ModSAF RWA attack (or Fire Modes) missions to determine how many PDUs are being transmitted and processed during the course of the mission, as well as the frequency at which the PDUs (entity state, appearance, fire, detonation, position etc.) are being updated, so as to assess where the traffic might be reduced or eliminated in order to avoid "choking" the network when these air missions are utilized.

2. Communication from MWTB SINCGARS (M1A2 and stand-alone radio, running DIS 2.03) was broken-up/ garbled at all CCTT crew positions.

Analysis: This anomoly appears to be related to the different PDU (transmit and signal) packet sizes between DIS 2.03 stand-alone SINCGARS and the DIS 2.04r+ CCTT SINCGARS. To match the packet sizes, the 2.03 packets contain "padding" (i.e. not real data) which, when read/processed by the CCTT SINCGARS, results in "choppy" or "broken" audio transmissions. This only occurs in radio transmissions from a DIS 2.03 SINCGARS to the CCTT SINCGARS. Radio transmissions in the other direction are loud and clear.

Corrective Action: The stand-alone SINCGARS radios can operate on either DIS protocol, regardless of what protocol its host simulator/device is running on. Therefore it is recommended that any stand-alone SINCGARS that must interplay with CCTT QS Modules operate on the DIS 2.04 protocol. However, if mixed protocols are necessary, it is recommended that Mod X be used to tether a DIS 2.04 SINCGARS to a DOS 2.03 simulator/device.

3. MWTB M1A2 went down at least once in four out of five test runs.

Analysis: M1A2 host computer cannot process data fast enough which causes buffers to fill up after approximately two (2) hours of operation, at which time the simulator goes down and must be re-initialized.

Corrective Action: Currently the host computer developer (Oasis Systems) is conducting an analysis intended to propose and evaluate methods of improving the host processor's performance.

4. DSI went down at least once during every test run.

Analysis: On two occasions, the stream size across the WAN was incorrectly set up. On one occasion a local lightning storm interrupted service temporarily. The last instance of interrupted service was due to the local T20 line at MWTB going down.

Corrective Action: None required.

5. ModSAF BRDM2 is invulnerable to tank main gun (120mm) fire, but can be destroyed by 7.62 coax machine gun.

Analysis: Survivability/vulnerability thresholds appear to be mismatched between certain ModSAF entities/weapon systems and the manned simulator weapon systems.

Corrective Action: Recommend investigation of ballistic/vehicle weapon enumerations to identify which entities (ModSAF, CCTT and/or M1A2) require modifications.

6. MWTB M1A2 crew observed CCTT Module floating above the terrain.

Analyisis: The Vistaworks S1000 (M1A2) and Primary 2 (CCTT) terrain databases are not precisely correlated in any axis, but most noticeably the Z axis. In addition, the CCTT Modules do not utilize "terrain clamping".

Corrective Action: Further investigation is required. However, the CDF Upgrade DO is currently tasked to develope a database to be used for correlation studies.

7. ModSAF MI28 helicopters appeared to MWTB M1A2 as M-109 vehicles.

Analysis: The M1A2 visual subsystem does not include the MI28 model and therefore assumed the "default" appearance of an M-109 Howitzer.

Corrective Action: Short-term fix would involve changing the enumeration of the MI28 to match the MI24 which is modeled on the M1A2. Long-term solution would be to add the MI28 entity model to the M1A2 visual subsystem.

5.2 Conclusions

DIS 2.03 and 2.04 devices can successfully interoperate, via Mod X, over the DSI with a fair degree of reliability. When the DSI went down, recovery was rapid, which kept interruption and down time to a minimum. However, device interoperability was significantly degraded due to the following functional and/or fidelity deficiencies:

1. Correlation between terrain databases, particularly the Z axis.
2. Inconsistent/incorrect entity states
3. Inconsistent/incorrect entity appearances
4. Incorrect vulnerability/survivability to enemy fire

5. Minimal number and type of available entity models (vehicles/aircraft) which can be identified by the different simulators.

Regarding the performance of the MWTB M1A2, the CDF Upgrade DO has been tasked to perform a Mini-Feasibility Analysis Study (Mini-FAS) with the objective of improving overall system performance/reliability.

5.3 Recommendations

Recommended that interoperability issues between ModSAF and CCTT be given the highest priority for investigation/resolution since these devices, when operating together, provide great versatility in supporting/enhancing/improving high fidelity training and experimentation. To facilitate this, additional controlled testing is recommended to identify and document other correlation, performance and/or fidelity anomolies between the devices for future investigation and resolution.

6. NOTES

6.1 Acronyms and Abbreviations

Acronym/Abbreviation	**Definition**
CCTT	Close Combat Tactical Trainer
CDF	Core DIS Facility
CPH	Commander's Popped Hatch
DIS	Distributed Interactive Simulation
DO	Delivery Order
DSI	Defense Simulation Internet
FDDI	Fiber Distributed Data Interface
LOS	Line of Sight
MC	Maintenance Console
MINI-FAS	Mini-Feasibility Analysis Study
Mod X	ModSAF Translator
ModSAF	Modular Semi-Automated Forces
MWTB	Mounted Warfare Testbed
N/A	Not Applicable
NLOS	Non-Line of Sight
OPFOR	Opposing Forces
STET	Operating System
OSF	Operational Support Facility
PDU	Protocol Data Unit
PUI	Project Unique Identifier

Acronym/Abbreviation	Definition
QS	Quick Start
RPN	Research Park Network
SAS	Single Attachment Station
SC	Single Channel
SIMNET	Simulation Network
SINCGARS	Single Channel Ground -To-Air Radio System
SME	Subject Matter Expert
SQ ON	Squelch On
STRICOM	Simulation, Training and Instrumentation Command
XCAU	Experimental Cell Adapter Unit
STET	STET

ADVANCED DISTRIBUTED SIMULATION TECHNOLOGY II (ADST II)

CDF UPGRADE DELIVERY ORDER 0013

APPENDIX C

TEST REPORT FOR THE QS MODULE INTEROPERABILITY TESTS AT OSF

FOR: **STRICOM**
12350 Research Parkway
Orlando, FL 32826-3224
N61339-96-D-0002
DI-MISC-80711

BY: **Lockheed Martin Corporation**
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ADSTII
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1. SCOPE

1.1 Purpose

This document describes the results of an interoperability test intended to evaluate the integration of M1A1 and M2M3 Close Combat Tactical Trainer (CCTT) Quick Start (QS) Modules with Commander's Popped Hatch (CPH) and a Maintenance Console (MC) at the Operational Support Facility (OSF), Orlando, Florida. The Tests addressed interoperability between the QS Modules and selected Distributed Interactive Simulation (DIS) Devices. The tests were organized into Groups which addressed visual, communication and limited tactical operability between devices. The OSF received one of each QS Module and one MC under the Core Distributed Interactive Simulation (DIS) Facilities (CDF) Upgrades Delivery Order (DO) 0013.

This test report is prepared in accordance with Data Item Description (DID) DI-MISC-80711.

The test procedures are contained in Appendix A of Test Plan ADST-II-CDRL-003R-9600290-A.

1.2 System Description

The M1A1 and M2M3 CCTT QS Modules provide high fidelity full crew interactive training by replicating the internal crew positions (Commander, Gunner, Loader (M1A1 only) and Driver compartment of the M1A1 Abrams Main Battle Tank and the M2M3 Bradley Fighting Vehicle. Functional subsystems include the Fire Control System, Weapons/Ammo System, Power System (electrical and hydraulic), Sound Generation System and Visual Display/Image Generator. The CPH feature allows the Commander to view the surrounding terrain from "outside" the vehicle through a bank of visual displays/screens on top of the trainer that provides a 360 degree field of view.

The MC serves as the exercise controller which allows the Instructor/Operator (I/O) to build, initialize, modify, suspend or terminate an exercise. The MC also provides the capabilities to establish the initial operating parameters/conditions for the CCTT Modules and to define initial environmental conditions.

1.3 Technical Overview

The CCTT QS Modules operate on the DIS 2.04r protocol while other DIS devices at the OSF operate on DIS 2.03. An Experimental Cell Adapter Unit (XCAU), also called the ModSAF Translator (Mod X), developed under this DO, enabled the CCTT and other DIS devices to interoperate. A key objective of the tests was to evaluate Mod X performance.

Other DIS devices used for the interoperability tests included Modular Semi-Automated Forces (ModSAF) workstations, Single Channel Ground and Airborne Radio Systems (SINCGARS) and a Dial-a-Tank reconfigurable simulator. These devices are all capable of running on either DIS protocol. For the tests, a ModSAF workstation and Dial-a-Tank were operating on DIS 2.03 while a second ModSAF, two SINCGARS and the CCTT Modules were operating on DIS 2.04.

2. REFERENCED DOCUMENTS

2.1 Government Documents

2.1.1 Data Item Description

DI-MISC-80711	Scientific and Technical Reports - Organization, Preparation and Production

2.1.2 Test Plan

ADST-II-CDRL-003R-9600290-A	Interoperability Tests for the QS Modules at OSF

3. TEST ENVIRONMENT

3.1 Test Components

3.1.1 ***Hardware Items/Simulators***

See Figure 1 for the interconnectivity between Hardware Items/Simulators, and Table I for a listing of Hardware Items/Simulators included within the test environment.

3.1.2 ***Software Items***

See Table I for a listing of the software items included within the test envrionment.

3.1.3 ***Databases***

See Table I for a listing of the databases included within the test envrionment.

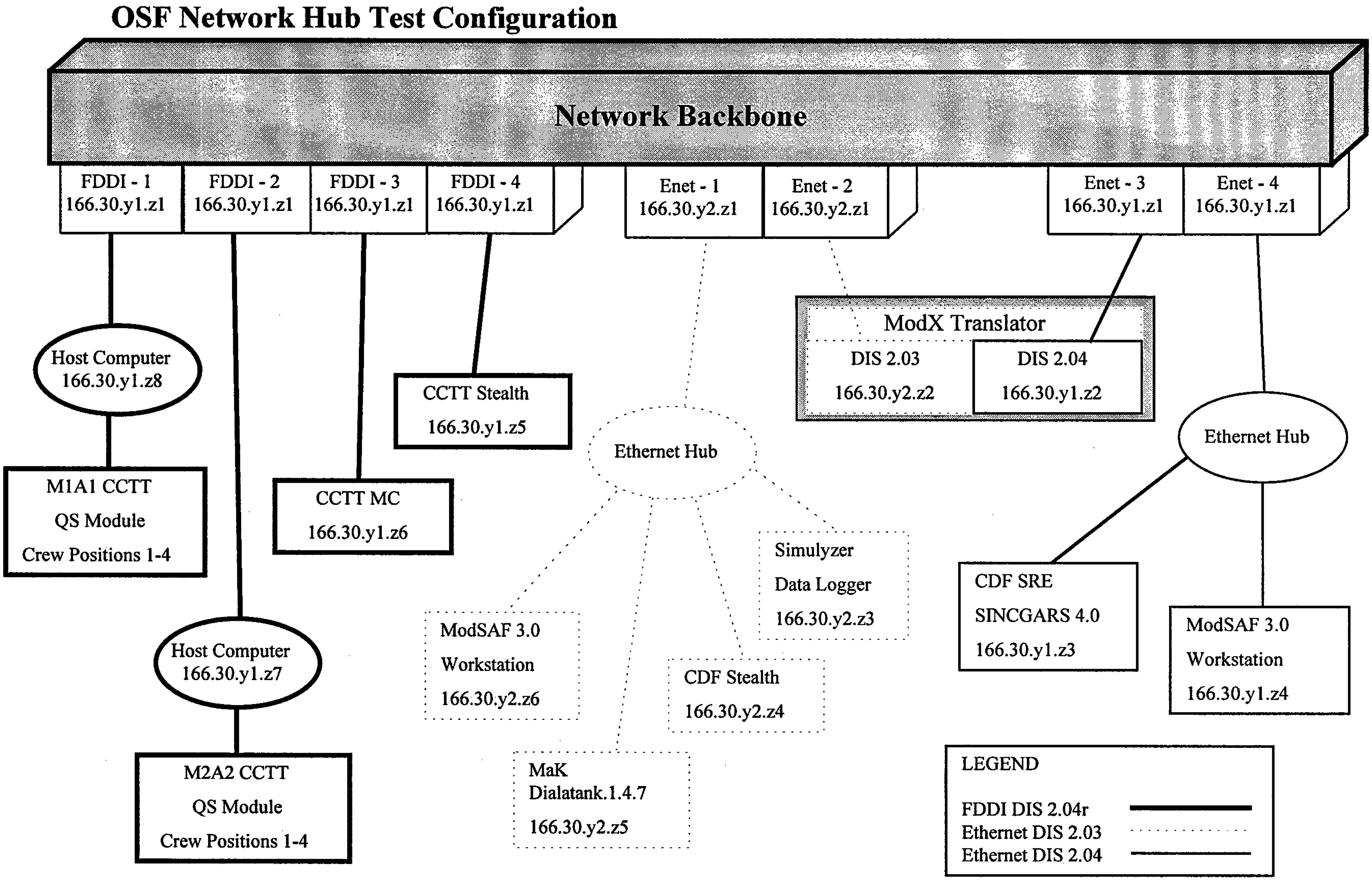

Figure 1. OSF Network Hub Test Configuration

	APPLICATIONS	QTY	H/W	DB	DIS	OS	NETWORK
1	CCTT Stealth	1	RISC6000/ ESIG3000	NTC GDF	2.04r	AIX 4.14	Ethernet
2	CDF SRE v4.1	2	SGI Indy R4600/133 MHz CPU w/ 96Mb RAM	NTC C4B	2.03 2.04	IRIX 5.2/6.2	Ethernet
3	Dial-A-Tank	1	SGI Indy R4400/100MHz CPU w/ 96 Mb RAM	NTC Flight Database	2.03	IRIX 5.3	Ethernet
4	M1A1 CCTT QS Module	1	RISC6000/ ESIG3000	GDF NTC ctdb	2.04r	AIX 4.14	FDDI Dual Attached
5	M2M3 CCTT QS Module	1	RISC6000/ ESIG3000	GDF NTC ctdb	2.04r	AIX 4.14	FDDI Dual Attached
6	ModSAF #1 (3.0)	1	SGI Indy R4600/133MHz CPU w/ 96 Mb RAM	NTC C7B Database	2.03	IRIX 5.2	Ethernet
7	ModSAF #2 (3.0)	1	SGI Indigo2/250MHz CPU w/ 128 Mb RAM	NTC C7B Database	2.04	IRIX 6.2	Ethernet
8	MC	1	RISC 6000	N/A	2.04r	AIX 4.14	Ethernet
9	Mod X Translator	1	Sun Sparc Ultra/166 Mhz CPU w/ 128 Mb RAM	N/A	2.03 2.04	Sun 5.5.1/ Solaris 2.5	FDDI SAS/Ethernet

Table I. OSF Test Components

3.2 Security

3.2.1 Classified Material

No classified or sensitive data, equipment, or other material was used to conduct or support the tests.

3.2.2 Access To Test Suite

Access to the test suite/environment was restricted to the equipment operators, Quality Assurance, SME/Observers and Data Recorders/Monitors assigned to support the test unless otherwise directed by the on-site Test Director/Manager.

3.2.3 Test Environment

All items within the test environment to include hardware, software and database elements under test were controlled by the on-site Test Director/Manager.

3.3 Test Organization

3.3.1 Test Organization by Groups

Test groups consisted of a series of tests which evaluated a specific area of system functionality. Test Plan ADST-II-CDRL-003R-00290-A consisted of four primary Test Groups as follows:

1. MC Initialization/Performance (Group I)
2. Communication Tests (Group II)
3. Visual/Line Of Sight (LOS)/Non Line Of Sight (NLOS) Tests (Group III)
4. Limited Tactical Operability Tests (Group IV)

3.3.2 Test Organization by Parts

Test groups were subdivided into Parts which identified each unique test within that group.

3.3.3 Project Unique Identifiers (PUI)

Test groups were identified by Roman numerals in consecutive sequence and parts were identified by numeric designators in consecutive sequence. For example, the PUI II-1 designated the first part of the second test group.

3.4 Test Methodology

3.4.1 Test Station

A Tactical Operation Center (TOC) was colocated with the MC and coordinated all testing. An entity association was established by tethering the TOC SINCGARS to a ModSAF entity. This identified the TOC as an active component "on the game board".

3.4.2 Test Sequence

After completion of the MC (Group I) Tests, each QS Module underwent groups II, III and IV tests. Test groups II thru IV were conducted in consecutive order and all parts of a group were completed before beginning the next group.

3.4.3 Initial Conditions

The following initial conditions were satisfied prior to beginning the tests:

1. All participating or support hardware/system components within the test environment were initialized and required Network cabling/connectivity between devices was completed.
2. Each active component of the test, to include manned DIS/QS simulators, TOC and ModSAF Friendly/OPFOR entities, were assigned an entity identification/ bumper number, location and operational status.
3. All SINCGARS radios (standalone and vehicle) were preset to operate in the Single Channel (SC) Mode and had loaded the same operating frequency on Channel 1.
4. All active components of the test, to include the manned DIS/QS simulators, Stealth device, and TOC/MC, were playing in the correct region/sector of the terrain database.
5. Support components, to include the Mod X, DISAT (optional) and Datalogger (optional), were properly set-up/configured to translate, capture/record, playback and analyze data as required.
6. CCTT QS Modules were operating in the Broadcast Mode enabling interplay with DIS Devices.

4. TEST IDENTIFICATION

4.1 MC Initialization/Performance (Group I)

This series of tests initialized the MC and the QS Modules and evaluated the capability to set up, start, suspend, and terminate an exercise. Refer to Section 4 of Test Plan ADST-II-CDRL-003R-9600290-A for a detailed description of each Part.

4.2 Communication Tests (Group II)

This series of tests evaluated two-way communication between each QS Module and the TOC/MC. A separate test of the Instuctor Voice Channel (IVC) was included to check the capability of overriding tactical communications and terrain propagation when IVC connection was made. In all Tests, the SINCGARS Radios and Vehicle Intercom Boxes were used to transmit and receive. Refer to Section 4 of Test Plan ADST-II-CDRL-003R-9600290-A for a detailed description of each Part.

4.3 Visual/LOS/NLOS Tests (Group III)

This series of tests evaluated interoperability between the QS Module, Dial-a-Tank, Stealth and ModSAF visual displays. The Objective of the Tests was to check interoperability between each Module and each DIS Device. Refer to Section 4 of Test Plan ADST-II-CDRL-003R-9600290-A for a detailed description of each Part.

4.4 Limited Tactical Operability Tests (Group IV)

This series of tests verified that the QS Modules could detect, engage and break contact with ModSAF enemy/OPFOR ground and air entities. Refer to Section 4 of ADST-II-CDRL-003R-9600290-A for a detailed description of each Part.

5. TEST RESULTS

5.1 Observations

1. CCTT Module is not damaged/destroyed by ModSAF OPFOR entities and certain ModSAF entities (BMP) are not damaged/destroyed by CCTT.

Analysis: Survivability/vulnerability thresholds appear to be mismatched between certain ModSAF entities/weapons systems and the CCTT weapon systems.

Corrective Action: Recommend investigation of Ballistic/vehicle weapon enumerations to identify which entities (ModSAF or CCTT) require modifications.

2. AAR Stealth exhibits MTBF of approximately 40-45 minutes.

Analysis: Anomaly appears to occur with OSF AAR Stealth only.

Corrective Action: Further investigation required.

3. ModSAF #2 (DIS 2.03) crashes intermittently.

Analysis: Dial-a-Tank appears to transmit a corrupted PDU. (This anomaly only occurred with the 2.03 ModSAF at OSF). It is also possible that the CCTT MC is sending an intermittent "stop" or "terminate" PDU back thru the Mod X. When ModSAF receives this PDU it will immediately exit/stop which resembles a system crash.

Corrective Action: Further investigation is required.

4. CCTT Driver's compartment overhead light is out.

Analysis: Bulb missing from overhead light.

Corrective Action: Bulb replaced 5/9/97. Status: Closed

5. Loader experiences difficulty reloading main gun (intermittent)

Analysis: Anomaly attributed to operator error as hull was incorrectly positioned for reloading rounds from on-board storage (ammo rack).

Corrective Action: None required. Status: Closed

6. Driver right side vision block is partially obscured by horizontal black and white bars.

Analysis: Visual subsystem unable to install mask or blank display.

Corrective Action: Recommend CCTT investigate re-design to correct problem.

7. Z Axis correlation is off by several meters between Primary 2 (CCTT) and CTDB 7 (ModSAF) terrain databases.

Analysis: The CTDB7 (ModSAF) and Primary 2 (CCTT) terrain databases are not precisely correlated in any axis, but most noticeably in the Z axis. ModSAF entities appear to CCTT crewmembers as “floating” above the terrain. Note that CCTT Modules do not incorporate a “terrain clamping” feature.

Corrective Action: Further investigation is required. However, the CDF Upgrade DO is currently tasked to develope a database to be used for correlation studies.

8. CCTT compass inoperative

Analysis: Anomoly attributed to operator error as 30 second time lapse is required before compass becomes operative.

Corrective Action: None required. Status: Closed

9. Few ModSAF entity models (vehicle/aircraft) can be recognized by CCTT Module.

Analysis: During development, the CCTT visual subsystem incorporated a limited number of entity models.

Corrective Action: Identify additional entity models compatible with ModSAF for incorporation in the CCTT visual subsytem.

10. CCTT and TOC1 (CDF SRE) could not communicate at maximum range (35km) even though ModSAF indicated open LOS.

Analysis: Correlation problem between terrain databases resulted in TOC1 entity being below ground which prevented communication regardless of open LOS.

Corrective Action: See corrective action under item # 7.

11. Radio A of A2ATD SRE #LM00802 (TOC1) is inoperable.

Analysis: N/A

Corrective Action: Radio turned in to LSE for maintenance on 5/15/97. Status: Closed

12. Vehicle movement as seen thru/on CCTT and AAR visual displays jerks back and forth.

Analysis: Anomaly may be due to inadequate visual update rate (currently 15 Hz)

Corrective Action: Further investigation required.

13. CPH Display is faded or colors are mismatched between channels

Analysis: Display alignment required.

Corrective Action: Alignment completed (on M1A1 module only). M2M3 did not exhibit some degree of misalignment. Status: Closed.

14. Range display on Gunner's Unity Window is backward (mirror image) and display is upside down. Also displays a double window.

Analysis: Window displays were installed backwards with focal point upside down. Double window was the result of misaligned visual displays.

Corrective Action: Corrective action was to be scheduled after completion of testing.

15. TIS reticle only one color (white). Should also have black reticle.

Analysis: Feature does not appear to be simulated. CCTT program is still investigating.

Corrective Action: Further investigation required.

16. When lasing on moving target, reticule is unstable (wavers).

Analysis: Known problem with stability of the visual subsystem.

Corrective Action: Further investigation required.

17. Gunner Computer Control Panel Door improperly functions (closing door does not deactivate computer in manual mode).

Analysis: Ballistic computer toggle switch recessed too far back in cabinet.

Corrective Action: Toggle switch adjusted on 6/4/97. Closing door now properly deactivates switch. Status: Closed.

18. TIS focus knob inoperable.

Analysis: Knob functionality is not simulated (component is cosmetic only).

Corrective Action: None required. Status: Closed

19. GAS displays GPS reticule (not ballistic reticules for HEAT or SABOT).

Analysis: Proximity sensor was blocked.

Corrective Action: Obstruction was removed 5/13/97. Status: Closed

20. Drift knobs (EL and AZ) do not null drift.

Analysis: CCTT program responded that it is uncertain whether or not this functionality is simulated.

Corrective Action: Further investigation required.

21. GAS filter inoperable.

Analysis: Filter functionality is not simulated (component is cosmetic only).

Corrective Action: None required. Status: Closed

22. CWS 50 CAL reticule is upside down.

Analysis: Anomaly appears in OSF M1A1 only.

Corrective Action: Pending software fix expected to correct this problem.

5.2 Conclusions

DIS 2.03 and 2.04 devices can successfully interoperate, via ModX, with a fair degree of reliability. Interconnectivity of devices over The Local Area Network (LAN) was maintained without interruption/down time. However, device interoperability was significantly degraded due to the following functional and/or fidelity deficiencies:

1. Correlation between terrain databases, particularly the Z axis.

2. Inconsistent/incorrect entity states.
3. Inconsistent/incorrect entity appearances.
4. Incorrect vulnerability/survivability to enemy fire.
5. Minimal number and type of available entity models (vehicles/aircraft) which can be identified by the different simulators.

5.3 Recommendations

Recommend that interoperability issues between ModSAF and CCTT be given the highest priority for investigation/resolution since these devices, when operating together, provide great versatility in supporting/enhancing/improving high fidelity training and experimentation. To facilitate this, additional controlled testing is recommended to identify and document other correlation, performance and/or fidelity anomolies between the devices for future investigation and resolution.

6. NOTES

6.1 Acronyms and Abbreviations

Acronym/Abbreviation	Definition
BIT	Built-In-Test
C4B	Compact Terrain Database, Version 4
C5B	Compact Terrain Database, Version 5
C7B	Compact Terrain Database, Version 7
CCTT	Close Combat Tactical Trainer
CDF	Core DIS Facility
CPH	Commander's Popped Hatch
CTDB	Compact Terrain Database
DIS	Distributed Interactive Simulation
DISAT	Distributed Interactive Simulation Analysis Tool
DO	Delivery Order
DRC	Daily Readiness Check
FDDI	Fiber Distributed Data Interface
GDF	General Database Format
GUI	Graphic User Interface
IG	Image Generator
LAN	Local Area Network
MC	Maintenance Console
MGRS	Military Grid Reference System
Mod X	ModSAF Translator
N/A	Not Applicable
NTC	National Training Center
OPFOR	Opposing Forces
OS	Operating System

Acronym/Abbreviation	Definition
OSF	Operational Support Facility
PIE	Programmaable Interface Electronics
PUI	Project Unique Identifier
PVD	Plan View Display
QS	Quick Start
SAS	Single Attachment Station
SINCGARS	Single Channel Ground and Airborne Radio System
SME	Subject Matter Expert
SRE	SINCGARS Radio Emulator
TOC	Tactical Operations Center
XCAU	Experimental Cell Adapter Unit

ADST-II-CDRL-CDF-9700241
September 26, 1997

ADVANCED DISTRIBUTED SIMULATION TECHNOLOGY II (ADST II)

CDF UPGRADE
DELIVERY ORDER 0013

APPENDIX D

TEST REPORT FOR THE CDF SINCGARS RADIO EMULATOR AT AVTB

FOR: **STRICOM**
12350 Research Parkway
Orlando, FL 32826-3224
N61339-96-D-0002
DI-MISC-80711

BY: **Lockheed Martin Corporation**
Lockheed Martin Information Systems
ADSTII
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1. SCOPE

1.1 Purpose

This document describes the results of an interoperability test conducted on upgraded Single Channel Ground and Airborne Radio System (SINCGARS) simulators, also called the SINCGARS Radio Emulator (SRE). The tests were organized into groups consisting of one standalone and three interoperability series. The tests were conducted on July 23 and 24,1997 at the Aviation Testbed (AVTB), Ft. Rucker, Alabama. A total of six (6) upgraded SREs were fielded at the AVTB under the Core Distributed Interactive Simulation (DIS) Facilities (CDF) Upgrade Delivery Order (DO) 0013.

This test report is prepared in accordance with Data Item Description (DID) DI-MISC-80711. The test procedures are contained in Appendix A of Test Plan ADST-II-CDRL-003R-9600305-B.

1.2 System Description

The SRE simulator models the radio equipment by means of a faceplate which replicates two radios, the bottom position called Radio A and the top position called Radio B. Each radio features a Control/Display Panel with LED alphanumeric display, a Radio Frequency (RF) switch, Function (FCTN) switch, Channel (CHAN) switch, Communications Security (COMSEC) switch, Dim (DIM) switch, Volume/Whisper (VOL/WHSP) control and Mode switch. Additional SRE hardware consists of the radio electronics (green) box, host platform, keyboard, mouse and headsets.

The SREs can operate on either DIS 2.03 or 2.04 protocol which enables them to communicate with DIS devices operating on either version of software. For this series of tests, all DIS devices were operating on 2.04 protocol.

1.3 Technical Overview

The CDF SRE was upgraded with a new version of the SINCGARS software (v. 4.1). The new software was developed to provide interoperability between older configurations of stand-alone or vehicle-mounted SINCGARS, and the CCTT SINCGARS. The new software also provides the older SINCGARS configurations with the CCTT Instructor Voice Channel (IVC) capability. The IVC allows the Instructor/Operator (I/O) to interrupt/override normal tactical communications and establish open-channel contact to and from any/all simulators connected to the IVC. The terrain propagation model and maximum range limitations are also overridden in the IVC mode. If the IVC connection is terminated, the radios automatically return to normal

(tactical) mode. The tests included two (2) CDF SREs, one (1) CDF SRM (GUI) and an RWA simulator configured with SINGARS radios at each crew position. A Modular Semi-Automated Forces (ModSAF) workstation was used to provide the terrain board and establish the vehicle entities to which the stand-alone radios were attached or tethered.

2. REFERENCED DOCUMENTS

2.1 Government Documents

2.1.1 Data Item Description

DI-MISC-80711	Scientific and Technical Reports - Organization, Preparation and Production

2.1.2 Test Plan

ADST-II-CDRL-003R-9600305-B	Test Plan for the SINCGARS Radio Emulator (SRE) at AVTB

3. TEST ENVIRONMENT

3.1 Test Components

3.1.1 Hardware Items/Simulators

See Table I for listing of Hardware Items/Simulators included within the test environment and Figure 1 for interconnectivity between Hardware Items/Simulators.

3.1.2 Software Items

See Table I for listing of software items included within the Test Environment.

3.1.3 Databases

See Table I for listing of databases included within the Test Environment.

3.1.4 Radio Operating Data

1. Single Channel (SC) Mode: None (operating frequencies were manually loaded).
2. Frequency Hopping (FH) Mode: FH Hopsets were loaded from a CDF SRE, serving as the Net Control Station (NCS), via Electronic Remote Fill (ERF) or Cold Start Net Opening.

AVTB Network Hub Test Configuration

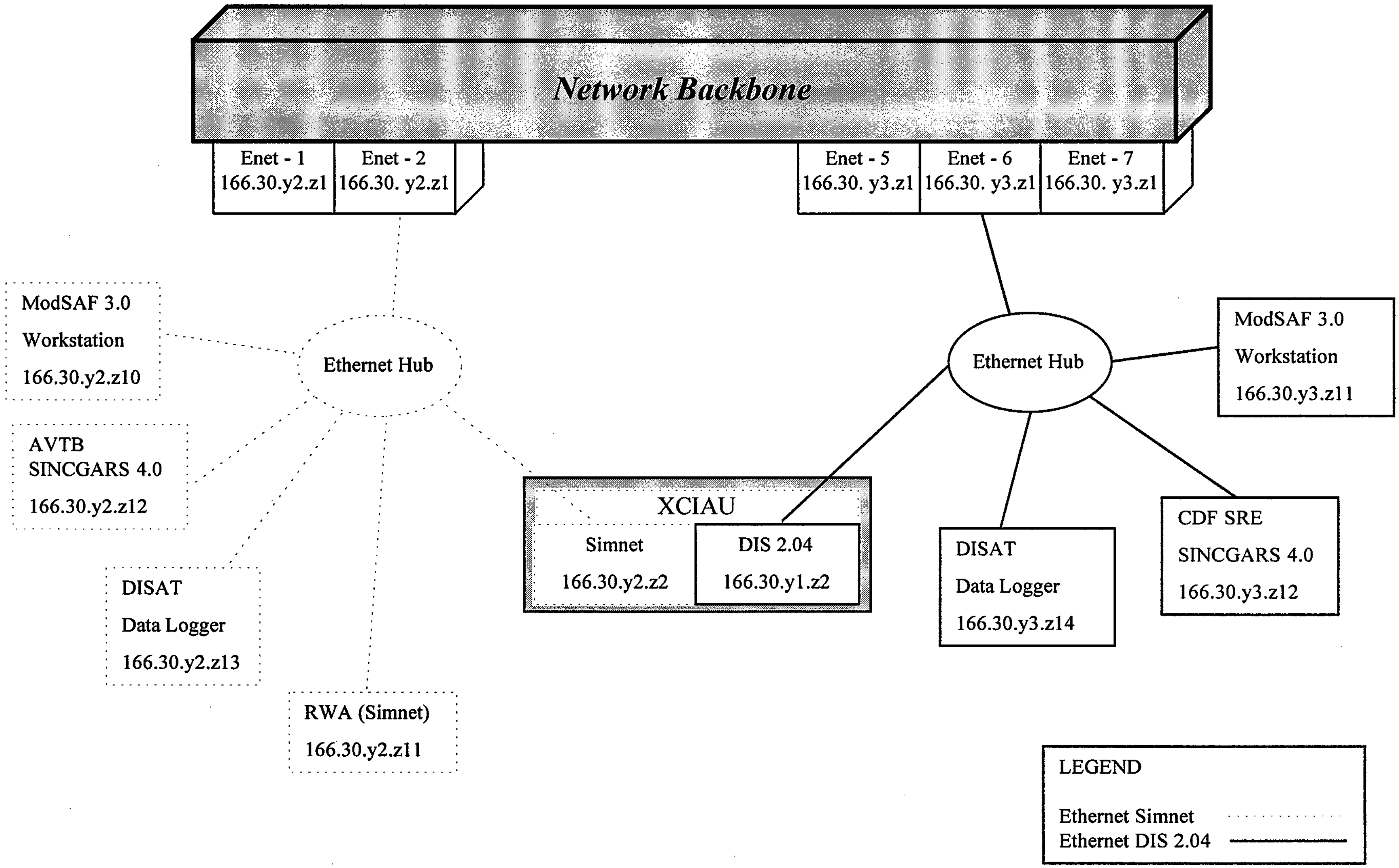

Figure 1. AVTB Network Hub Test Configuration

	APPLICATIONS	QTY	H/W	DB	DIS	OS	NETWORK
1	CDF SRE (TOC 1/NCS) SINCGARS 4.1	2	SGI Indy R4600/133 MHz CPU w/ 96 Mb RAM	NTC C4B	2.04	IRIX 5.2/6.2	Ethernet
2	CDF SRM (TOC 2) SINCGARS 4.1	1	SGI Indy R4600/133 MHz CPU w/ 96 Mb RAM	NTC C4B	2.04	IRIX 5.2/6.2	Ethernet
3	RWA Simulator	1	BBN GT111	NTC C4B	SIMNET	GTOS 8.0	Ethernet
4	RWA Sim Radio	1	SGI Indy R4600/133 MHz CPU w/ 96 Mb RAM	NTC C4B	2.04	IRIX 5.2/6.2	Ethernet
5	XCIAU	1	SGI Indy R4400/100 MHz CPU w/ 96 Mb RAM	n/a	DIS 2.04 SIMNET	IRIX 5.3	FDDI SAS/Ethernet
6	ModSAF 3.0	1	SGI Indy R4400/100 MHz CPU w/ 96 Mb RAM	NTC C7B	2.04	IRIX 5.3	Ethernet

Table I. AVTB Test Components

3.2 Security

3.2.1 Classified Material

No classified or sensitive data, equipment, or other material was used to conduct or support the tests.

3.2.2 Access To Test Suite

Access to the test suite/environment was restricted to the equipment operators, SME/Observers, Quality Assurance, and Data Recorders assigned to support the test unless otherwise directed by the on-site Test Manager/Director.

3.2.3 Test Environment

All items within the Test Environment to include hardware, software and database elements under test were controlled by the on-site Test Director.

3.3 Test Organization

3.3.1 Test Organization by Groups

Test groups consisted of a series of tests which evaluated a specific area of system functionality. Test Plan ADST-II-CDRL-003R-9600245-B contains four (4) primary test groups as follows:

1. Standalone Tests (Group I)
2. Two-Way Communication Tests-Single Channel (SC) Operating Mode (Group II)
3. Two-Way Communication Tests-Frequency Hopping (FH) Operating Mode (Group III)
4. Instructor Mode/IVC and Clearing FH Data Tests (Group IV)

3.3.2 Test Organization by Parts

Test groups were subdivided into parts which identified each unique test within that group.

3.3.3 Project Unique Identifiers (PUI)

Test groups were identified by Roman numerals in consecutive sequence and parts were identified by numeric designators in consecutive sequence. The PUI II-1 designated the first part of the second test group.

3.4 Test Methodology

3.4.1 Test Station

A Tactical Operation Center (TOC) was established as the Test Station which included the associated entity (i.e.identification) required for each CDF SRE under test.

3.4.2 Test Sequence

1. Group I: Each CDF SRE was tested sequentially at the Test Station with the objective of completing all tests on the first SRE, removing it from the network and installing the next SRE to be evaluated. All six (6) CDF SREs underwent Group I Tests.
2. Groups II, III, and IV: One CDF SRE was designated as the First Article Test (FAT) unit and underwent the tests of Group II, III, and IV. A second CDF SRE was utilized as the Net Control Station (NCS) to support Group III tests.

4. TEST IDENTIFICATION

4.1 Stand-Alone Tests (Group I)

This series of tests was intended to evaluate the performance of specific functions of the SREs that did not involve interplay with other simulators/equipment. This test group was conducted on all CDF SREs, to include Radios A and B of each unit, and consisted of four (4) Parts.. Refer to section 4 of Test Plan ADST-II-CDRL-003R-9600305-B for a detailed description of each Part.

4.2 Two Way Communication Tests-Single Channel Mode (Group II)

This series of tests evaluated two way communication between a stand-alone CDF SRE, a standalone CDF SRM (GUI) and an RWA Simulator configured with SINCGARS radios at each crew position. The CDF SRM replaced the A2ATD SINCGARS model, originally called for in the Test Plan, which was not available for the test All SINCGARS radios were upgraded with CDF SINCGARS version 4.1 software. All tests were conducted with the radios operating in the Single Channel Mode. This Group consisted of four (4) Parts. Refer to section 4 of Test Plan ADST-II-CDRL-003R-9600305-B for a detailed description of each Part.

4.3 Interoperability Tests-Frequency Hopping Mode (Group III)

This series of tests addressed the same equipment interoperability as Group II except that all radios were operating in the Frequency Hopping Mode. The same radios/devices from Group II Testing were used for Group III Testing with the addition of one (1) more CDF SRE which served as the NCS required to perform ERF. . This group consisted of three (3) Parts. Refer to section 4 of Test Plan ADST-II-CDRL-003R-9600305-B for a detailed description of each Part.

4.4 Instructor Mode/IVC Tests and Clearing FH Data (Group IV)

This series of tests evaluated communication between devices when the SRE Instructor Mode or Instructor Voice Channel (IVC) was enabled, to include the capability of overriding terrain propagation models, normal tactical communications and maximum range limitations. This series also verified the capability to clear FH data from the SRE. Group IV consisted of two (2) Parts. Refer to section 4 of Test Plan ADST-II-CDRL-003R-9600305-B for a detailed description of each Part.

5. TEST RESULTS

5.1 Observations

The tests were conducted successfully with no observed failures. One (1) problem was encountered during conduct of the test which was attributed to procedural error. The problem involved proper set-up and execution of ERF from the NCS in preparation for the commo tests in FH mode. The procedural problems were corrected and the equipment functioned properly. Appropriate red-line corrections were captured for incorporation into the final submittal of Test Plan ADST-II-CDRL-003R-0096305-B.

5.2 Conclusions

The AVTB SRE tests demonstrated that SINCGARS radios of different configurations can interoperate successfully when running the CDF version 4.1 software. The tests also demonstrated that when IVC is enabled, the I/O station can connect to the different SINCGARS configurations (stand-alone and/or vehicle-mounted), which will then override tactical communications, switch settings, operating modes, range limitations and terrain propagation models until disconnected.

5.3 Recommendations

Recommend that additional controlled testing, over a minimum eight (8) hour period, be conducted at AVTB involving ten (10) or more stand-alone SREs and two Advanced Simulation Technology Inc. (ASTi) radio systems, with each ASTi controlling three (3) RWA Simulators. The primary purpose of these tests is to stress the network and uncover possible “choke points” on the LAN which will result in “abnormal terminations” (crashes) of SINCGARS processes.

6. NOTES

6.1 Acronyms and Abbreviations

Acronym/Abbreviation	Definition
AVTB	Aviation Testbed
ASTI	Advanced Simulation Technology Incorporated
C4B	Compact Terrain Database Version 4
C5B	Compact Terrain Database Version 5
C7B	Compact Terrain Database Version 7
CCTT	Close Combat Tactical Trainer
CDF	Core DIS Facility
CHAN	Channel
CLR	Clear
CTDB	Compact Terrain Database
DIS	Distributed Interactive Simulation
DO	Delivery Order
ERF	Electronic Remote Fill
FAT	First Article Test
FDDI	Fiber Distributed Data Interface
FH	Frequency Hopping
GUI	Graphical User Interface
IVC	Intructor Voice Channel
NCS	Net Control Station
OSF	Operational Support Facility
PUI	Project Unique Identifier
QS	Quick Start
RWA	Rotary Wing Aircraft
SAS	Single Attachment Station
SC	Single Channel
SGI	Silicon Graphics Incorporated
SIMNET	Simulator Networking
SINCGARS	Single Channel Ground and Airborne Radio System
SME	Subject Matter Expert
SRE	SINCGARS Radio Emulator
STRICOM	Simulation, Training and Instrumenation Command.
SYNC	Synchronize

Acronym/Abbreviation	**Definition**
TOC	Tactical Operations Center
XCIAU	Experimental Cell Interface Adapter Unit

ADST-II-CDRL-CDF-9700241
September 26, 1997

ADVANCED DISTRIBUTED SIMULATION TECHNOLOGY II (ADST II)

CDF UPGRADE
DELIVERY ORDER 0013

APPENDIX E

TEST REPORT FOR THE QS MODULE INTEROPERABILITY TESTS AT LWTB

FOR: **STRICOM**
12350 Research Parkway
Orlando, FL 32826-3224
N61339-96-D-0002
DI-MISC-80711

BY: **Lockheed Martin Corporation**
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1. SCOPE

1.1 Purpose

This document describes the results of an interoperability test intended to evaluate the interface/interplay of M1A1 and M2M3 Close Combat Tactical Trainer (CCTT) Quick Start (QS) Modules, Commander's Popped Hatch (CPH) configuration with other Distributed Interactive Simulation (DIS) Devices. The tests were organized into Groups which addressed visual, communication and limited tactical operations between devices. The tests were conducted at the Land Warrior Testbed (LWTB), Ft. Benning, Georgia. A total of 2 CCTT QS CPH Modules (1 M1A1 and 1 M2M3) were fielded at the LWTB under the Core Distributed Interactive Simulation (DIS) Facilities (CDF) Upgrade Delivery Order (DO) 0013

This test report is prepared in accordance with Data Item Description (DID) DI-MISC-80711. The test procedures are contained in Appendix A of Test Plan ADST-II-CDRL-003R-9600302-B.

1.2 System Description

Thr M1A1 and M2M3 CCTT QS Modules provide high fidelity full crew interactive training by replicating the internal crew positions (Commander, Gunner, Loader (M1A1 only) and Driver compartment of the M1A1 Abrams Main Battle Tank and the M2M3 Bradley Fighting Vehicle. Functional subsystems include the Fire Control System, Weapons/Ammo System, Power System (electrical and hydraulic), Sound Generation System and Visual Display/Image Generator. The CPH feature allows the Commander to view the surrounding terrain from "outside" the vehicle through a bank of visual displays/screens on top of the trainer that provides a 360 degree field of view.

The Line Of Sight Anti-Tank Simulator (LOSAT) is currently being re-configured from the M2 (tracked) chassis to the High Mobility Multi-Wheeled Vehicle (HMMV) chassis. This conversion replicates the Commander's and Driver's positions while eliminating the Gunner's position. During operation, both crew positions are interactive to include Single Channel Ground and Airborne Radio Systems (SINCGARS) headset and intercom box for internal and external (tactical) communication.

1.3 Technical Overview

The CCTT QS Modules operate on the DIS 2.04(r+) version of software while the LOSAT Simulator operates on DIS 2.03. The Modular Semi-Automated Forces (ModSAF) workstations and the SINCGARS radios can operate on either DIS protocol. An Experimental Cell Adapter Unit (XCAU), also called the ModSAF Translator (MOD X), was developed under this DO to translate standard DIS 2.03 Protocol Data Units (PDUs) to DIS 2.04 and vice versa, allowing the

CCTT and DIS 2.03 devices to interoperate. In addition, the MOD X provided interoperability between two ModSAF workstations, one operating on DIS 2.04 as the Test Control Station, and the other operating on DIS 2.03 as a Planned View Display (PVD). A key objective of the tests was to evaluate device interoperability, over the Local Area Network (LAN), thru the MOD X.

2. REFERENCED DOCUMENTS

2.1 Government Documents

2.1.1 Data Item Description

DI-MISC-80711	Scientific and Technical Reports - Organization, Preparation and Production

2.1.2 Test Plan

ADST-II-CDRL-003R-9600302-B	Test Plan for the QS Module Interoperability Tests at LWTB

3. TEST ENVIRONMENT

3.1 Test Components

3.1.1 Hardware Items/Simulators

See Figure 1 for the interconnectivity between Hardware Items/Simulators, and Table I for a listing of Hardware Items/Simulators included within the test environment.

3.1.2 Software Items

See Table I for a listing of the software items included within the test environment.

3.1.3 Databases

See Table I for a listing of the databases included within the test environment.

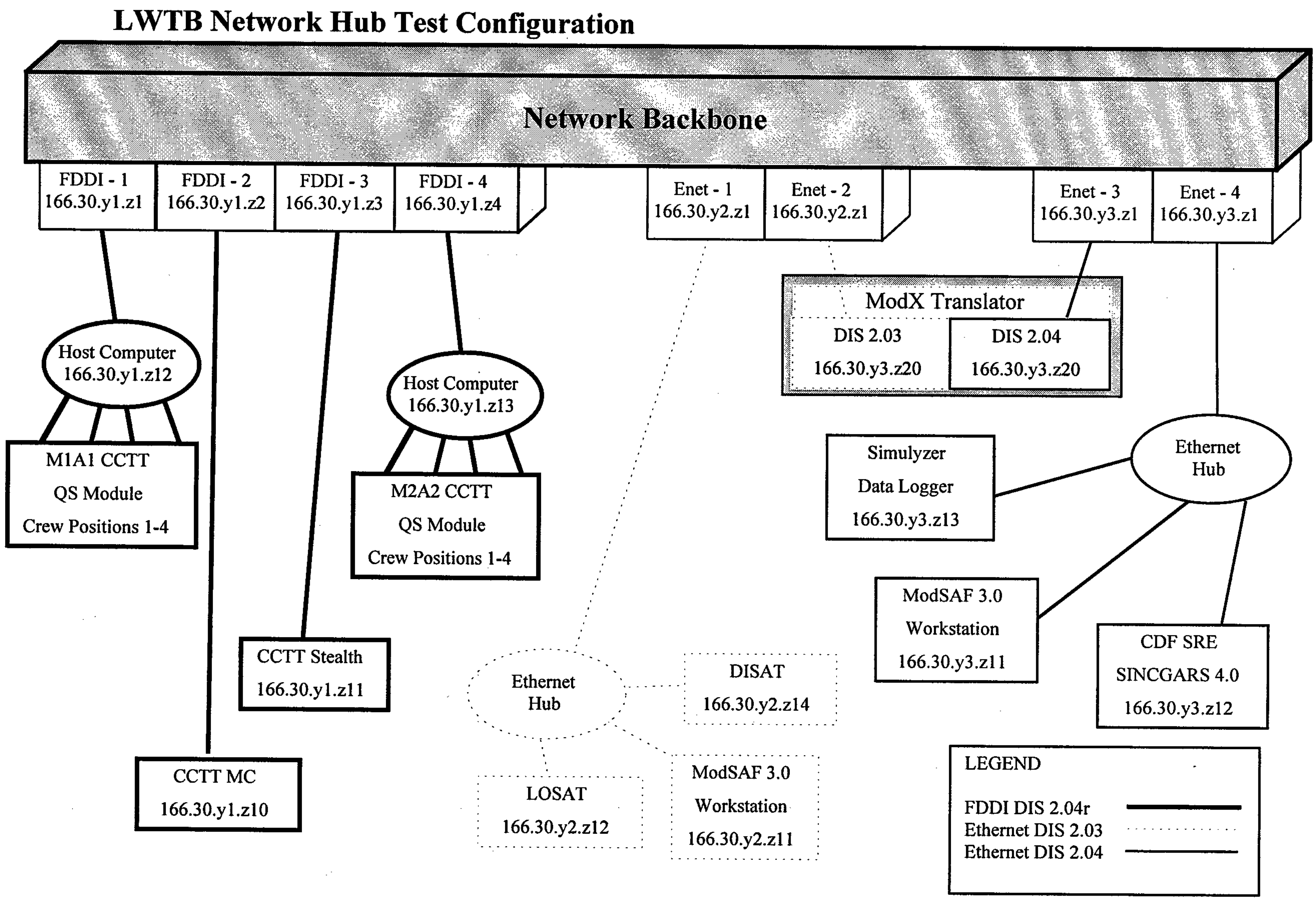

Figure 1. LWTB Network Hub Test Configuration

	APPLICATIONS	QTY	H/W	DB	DIS	OS	NETWORK
1	CCTT Stealth	1	RISC 6000/ ESIG 3000	NTC GDF	2.04r	AIX 4.14	FDDI
2	CDF SRE SINCGARS 4.0	1	SGI Indy R4600/133 MHz CPU w/ 96 Mb RAM	NTC C4B	2.03 2.04	IRIX 5.2/6.2	Ethernet
3	ModSAF 3.0	2	SGI Indy R4600/133 MHz CPU w/ 96 Mb RAM	NTC C7B	2.03 2.04	IRIX 5.3	Ethernet
4	LOSAT	1	2 SGI ONYX IGs	Vistaworks NTC S1000	2.03	IRIX 5.2	10B5 Ethernet AUI Conn.
5	M1A1 CCTT QS Module	1	RISC6000/ ESIG3000	NTC GDF ctdb	2.04r	AIX 4.14	FDDI Single Attached
6	M2M3 CCTT QS Module	1	RISC6000/ ESIG3000	NTC GDF ctdb	2.04r	AIX 4.14	FDDI Single Attached
7	MC	1	RISC 6000	n/a	2.04r	AIX 4.14	FDDI
8	Mod X Translator	1	SUN Sparc Ultra/166 MHz CPU w/ 128 Mb RAM	n/a	2.03 2.04	SUN 5.5.1/ Solaris 2.5	FDDI SAS/Ethernet

Table I. LWTB Test Components

3.2 Security

3.2.1 Classified Material

No classified or sensitive data, equipment, or other material was used to conduct or support the tests.

3.2.2 Access To Test Suite

Access to the test suite/environment was restricted to the equipment operators, Quality Assurance, SME/Observers and Data Recorders/Monitors assigned to support the test unless otherwise directed by the on-site Test Director/Manager.

3.2.3 Test Environment

All items within the Test Environment to include hardware, software and database elements under test were controlled by the on-site Test Director/Manager.

3.3 Test Organization

3.3.1 Test Organization by Groups

Test Groups consisted of a series of tests which evaluated a specific area of system functionality. Test Plan ADST-II-CDRL-003R-9600302-B consisted of three primary Test Groups as follows:

1. Communication Tests (Group I)
2. Visual/Line Of Sight (LOS)/Non Line Of Sight (NLOS) Tests (Group II)
3. Limited Tactical Operations Tests (Group III)

3.3.2 Test Organization by Parts

Test Groups were subdivided into Parts which identified each unique test within that Group.

3.3.3 Project Unique Identifiers (PUI)

Test Groups were identified by Roman Numerals in consecutive sequence and Parts were identified by numeric designators in consecutive sequence. The PUI II-1 designated the first Part of the second Test Group.

3.4 Test Methodology

3.4.1 Test Station

A Tactical Operation Center (TOC) was set up as the coordination point for all testing. An entity association (i.e. bumper number) was assigned to identify the TOC as an active component "on the game board". A CDF SRE served as the TOC.

3.4.2 Test Sequence

Each M1A1 and M2M3 QS Module underwent Groups I, II and III Tests. The test groups were conducted in consecutive order and all parts of a group were completed before beginning the next group.

3.4.3 Initial Conditions

The following initial conditions were satisfied prior to beginning the tests:

1. All participating or support hardware/system components within the test environment were initialized and required Network cabling/connectivity between devices was completed.
2. Each active component of the test, to include manned DIS/QS simulators, TOC and ModSAF Friendly/OPFOR entities, were assigned an entity identification/ bumper number, location and operational status.
3. All SINCGARS radios (standalone and vehicle) were preset to operate in the Single Channel (SC) Mode and had loaded the same operating frequency on Channel 1.
4. All active components of the test, to include the manned DIS/QS simulators, Stealth device, and TOC, were playing in the correct region/sector of the terrain database.
5. Support components, to include the XCAU, DISAT and Datalogger, were properly set-up/configured to translate, capture/record, playback and analyze data as required.
6. M1A1 and M2M3 QS Modules were operating in the Broadcast Mode enabling interplay with DIS Devices.

4. TEST IDENTIFICATION

4.1 Communication Tests (Group I)

This series of tests evaluated two-way communication between each QS Module, with the LOSAT and the TOC. In all tests, the SINCGARS Radios and vehicle intercom boxes were used to transmit and receive between vehicles/stations. The objective of these tests was to verify communications interoperability of each QS Module with the TOC and LOSAT. Refer to Section 4 of Test Plan ADST-II-CDRL-003R-9600302-B for a detailed description of each Part.

4.2 Visual/LOS/NLOS Tests (Group II)

This series of tests evaluated visual/LOS/NLOS interoperability between the QS Modules, LOSAT, STEALTH and ModSAF visual displays. The objective of these tests was to evaluate interoperability between each QS Module and the DIS Devices. Refer to Section 4 of Test Plan ADST-II-CDRL-003R-9600302-B for a detailed description of each Part.

4.3 Limited Tactical Operability Tests (Group III)

This series of tests verified that each QS Module could detect, engage and break contact with ModSAF enemy/OPFOR ground and air entities while the LOSAT observed the events. Refer to Section 4 of Test Plan ADST-II-CDRL-003R-9600302-B for a detailed description of each Part.

5. TEST RESULTS

5.1 Observations

1. At LOSAT Gunner's position, radio A is inoperable and the INT setting on the Intercom Box does not cut off outside communication.

Analysis: The problem with radio A appeared to be a bad circuit card. The problem with the Intercom Box appeared to be a faulty selector switch.

Corrective Action: The radio and Intercom Box were to be scheduled for maintenance shortly after completion of the test.

2. LOSAT could not move (i.e. be driven) during exercises.

Analysis: This anomoly appears to be the result of the host computer's inability to recognize soil models/terrain types within the NTC S1000 terrain database.

Corrective Action: Further investigation is required to confirm the analysis. A temporary modification to the operating software will be necessary until a new release becomes available. (Note: This same anomoly was encountered with the MWTB M1A2 when operating on the same terrain database. A temporary software fix was developed locally to resolve the problem).

3. CCTT M1A1 could not move (Driver's throttle inoperable).

Analysis: The problem was traced to a faulty potentiometer. Attempts to adjust the pot were unsuccessful.

Corrective Action: Replacement of the component was to be scheduled shortly after completion of the test.

4. LOSAT entity appearance on ModSAF does not change after vehicle is damaged or destroyed.

Analysis: The entity state and appearance PDUs are not correctly correlated between the two systems.

Corrective Action: Further investigation is required to determine which device/software (or both) should be modified.

5. LOSAT SINCGARS radios are still operable after vehicle is destroyed.

Analysis: The entity state PDU is not correctly correlated between the SINCGARS radio and LOSAT to which it is tethered.

Corrective Action: Further investigation is necessary to determine which device/software (or both) should be modified.

6. M1A1 driver's compartment left side monitor is out.

Analysis: The monitor had been removed for maintenance prior to the test.

Corrective Action: Replacement of the monitor was to be scheduled shortly after completion of the test.

7. M2M3 driver's compartment far left side monitor is out.

Analysis: This monitor had also been removed for maintenance prior to the test.

Corrective Action: Replacement was to be scheduled shortly after completion of the test.

8. SINCGARS IVC connection to LOSAT and CCTT M1A1 terminated during conduct of the ground engagements.

Analysis: This anomoly was attributed to operator error as the IVC "disconnect" option was inadvertantly selected during the gound-to-ground tactical operations tests.

Corrective Action: None required. Status: Closed

9. CCTT M1A1 could not maintain boresight setting at Gunner's position.

Analysis: Several attempts were made to properly set the boresight which involves alignment of the Muzzle Reference Sensor (MRS) with the Gunner's Primary Sight Reticles. However, the alignment could not be "locked in" which resulted in eventual boresight "drift".

Corrective Action: Further functional testing is necessary to determine whether the anomoly is related to a hardware and/or software deficiency.

10. Z axis not correlated between LOSAT, CCTT and ModSAF terrain databases.

Analysis: The three terrain databases (CTDB7, Primary 2 and NTC S1000) are not precisely matched or correlated in any axis but particularly in the Z axis. The resulting visual display shows certain vehicles/entities "floating" above the terrain while other entities are partially or completely hidden below the terrain.

Corrective Action: Further investigation is required. However, the CDF Upgrade DO is currently tasked to develope a database to be used for coorelation studies.

5.2 Conclusions

DIS 2.03 and 2.04 devices can successfully interoperate, via ModX, with a fair degree of reliability. Interconnectivity of devices over The Local Area Network (LAN) was maintained without interruption/down time. However, device interoperability was significantly degraded due to the following functional and/or fidelity deficiencies:

1. Correlation between terrain databases, particularly the Z axis.
2. Inconsistent/incorrect entity states.
3. Inconsistent/incorrect entity appearances.
4. Incorrect vulnerability/survivability to enemy fire.
5. Minimal number and type of available entity models (vehicle/aircraft) which can be identified by the different simulators.
6. Inability of LOSAT and CCTT M1A1 to move around the terrain database (other than instant move).

5.3 Recommendations

Recommend that interoperability issues between ModSAF and CCTT be given the highest priority for investigation/resolution since these devices, when operating together, provide great versatility in supporting/enhancing/improving high fidelity training and experimentation. To facilitate this, additional controlled testing is recommended to identify and document other correlation, performance and/or fidelity anomolies between the devices for future investigation and resolution.

6. NOTES

6.1 Acronyms and Abbreviations

Acronym/Abbreviation	Definition
A2ATD	Anti-Armor Advanced Technology Demonstration
C4B	Compact Terran Database Version 4
C7B	Compact Terran Database Version 7
CCTT	Close Combat Tactical Trainer
CDF	Core DIS Facility
CPH	Commander's Popped Hatch
CTDB	Compact Terrain Database
DIS	Distributed Interactive Simulation
DISAT	Distributed Interactive Simulation Analysis Tool
DO	Delivery Order
FAT	First Article Test
FDDI	Fiber Distributed Data Interface
GDF	Generic Database Format
GUI	Graphical User Interface
HMMV	High Mobility Multi-Wheeled Vehicle
IG	Image Generator
IVC	Instructor Voice Channel
LOS	Line of Sight
LOSAT	Line Of Sight AntiTank
LWTB	Land Warrior TestBed
MC	Maintenance Console
ModSAF	Modular Semi-Automated Forces
Mod X	ModSAF Translator
N/A	Not Applicable
NLOS	Non-Line of Sight
NTC	National Training Center
OS	Operating System
PUI	Project Unique Identifier
PVD	Planned View Display
QS	Quick Start
SAS	Single Attachment Station
SC	Single Channel

Acronym/Abbreviation	Definition
SD	Standalone Double
SINCGARS	Single Channel Ground-to-Air Radio System
SGI	Silicon Graphics Incorporated
SME	Subject Matter Expert
SRE	SINCGARS Radio Emulator
TOC	Tactical Operations Center
XCAU	Experimental Cell Adapter Unit